MODEL IM-1212 Digital Multimeter

HEATHKIT®

ASSEMBLY MANUAL

HEATH COMPANY BENTON HARBOR, MICHIGAN

Model IM-1212 Digital Multimeter

HEATHKIT®

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595-1725

PRICE $2.00

Dear Customer:

The Heathkit electronic product you have purchased is one of the best performing electronic products in the world.

Here's how we aim to keep it that way:

Your Heathkit Warranty

During your first 90 days of ownership, any parts which we find are defective, either in materials or workmanship, will be replaced or repaired free of charge. And we'll pay shipping charges to get those parts to you — anywhere in the world.

If we determine a defective part has caused your Heathkit electronic product to need other repair, through no fault of yours, we will service it free — at the factory, at any retail Heathkit Electronic Center, or through any of our authorized overseas distributors.

This protection is exclusively yours as the original purchaser. Naturally, it doesn't cover damage by use of acid-core solder, incorrect assembly, misuse, fire, flood or acts of God. But, it does insure the performance of your Heathkit electronic product anywhere in the world — for most any other reason.

After-Warranty Service

What happens after warranty? We won't let you down. If your Heathkit electronic product needs repairs or you need a part, just write or call the factory, your nearest retail Heathkit Electronic Center, or any Heath authorized overseas distributor. We maintain an inventory of replacement parts for each Heathkit model at most locations — even for many models that no longer appear in our current product line-up. Repair service and technical consultation are available through all locations.

We hope you'll never need our repair or replacement services, but it's nice to know you're protected anyway — and that cheerful help is nearby.

Sincerely,

HEATH COMPANY
Benton Harbor, Michigan 49022

Prices and specifications subject to change without notice.

Assembly and Operation of the

HEATHKIT

DIGITAL MULTIMETER

MODEL IM-1212

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HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

INTRODUCTION

Your Heathkit Model IM-1212 Digital Multimeter will accurately measure voltage, current, and resistance values, and display them on cold-cathode tubes and indicator lamps. Solid-state circuitry is used throughout the instrument for reliability and compactness.

Four ranges measure voltage and current, both AC and DC. The voltage ranges are 2, 20, 200, and 2k (2000) volts, although the maximum input voltages are limited to 1000 volts DC and 700 volts (rms) AC. The current ranges for both AC and DC are 2, 20, 200, and 2k (2000) mA (2 amperes). The five resistance ranges available are 200 ohms and 2, 20, 200, and 2k (2000) kilohms (2 megohms).

All DC voltage ranges have a one megohm input impedance so they do not load the circuit being measured. The voltage and current ranges provide an overrange indication by illuminating an indicator lamp. The decimal point is automatically located for each range by the setting of the Range switch.

Overload protection is provided by fuses on the current and resistance inputs, and the AC power line. A 3-wire polarized line cord is used, with the grounded wire connected directly to the chassis and cabinet for user protection. The input C (common) jack is not connected to the chassis. Dual transformer primary windings permit you to wire the multimeter for either 120 or 240 volts AC, 50-60 Hz.

The multimeter is housed in a low-profile, aluminum cabinet. The convenience, versatility, and accuracy of this Digital Multimeter make it a most desirable instrument for the lab, service shop, or ham shack.

Refer to the "Kit Builders Guide" for complete information on unpacking, parts identification, tools, wiring, soldering, and step-by-step assembly procedures.

PARTS LIST

Unpack the parts and check each one against the following list. The key numbers correspond to the numbers on the Parts Pictorial. Any part that is packaged in an individual envelope with a part number on it should be placed back in its envelope, after you identify it, until it is called for in a step. Do not discard any packing materials until all parts are accounted for.

step. Do not discard any packing materials until all parts are accounted for.

To order replacement parts, refer to the "Price Each" column and use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of the Manual.

RESISTORS

1/2-Watt, 10%

NOTE: 10% resistors have a fourth color band of silver.

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
A1	1-18	1	5600 Ω (green-blue-red)	.15
A1	1-21	2	15 kΩ (brown-green-orange)	.15
A1	1-102	2	82 kΩ (gray-red-orange)	.15
A1	1-121	2	120 kΩ (brown-red-yellow)	.15
A1	1-34	1	680 kΩ (blue-gray-yellow)	.15
A1	1-40	3	10 MΩ (brown-black-blue)	.15

1/2-Watt, 5%

NOTE: 5% resistors have a fourth color band of gold.

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
A1	1-123	2	100 Ω (brown-black-brown)	.15
A1	1-147	1	220 Ω (red-red-brown)	.15
A1	1-94	5	390 Ω (orange-white-brown)	.15
A1	1-172	6	1000 Ω (brown-black-red)	.15
A1	1-57	2	2200 Ω (red-red-red)	.15
A1	1-122	3	3300 Ω (orange-orange-red)	.15
A1	1-43	3	4700 Ω (yellow-violet-red)	.15
A1	1-114	2	8200 Ω (gray-red-red)	.20
A1	1-105	3	10 kΩ (brown-black-orange)	.15

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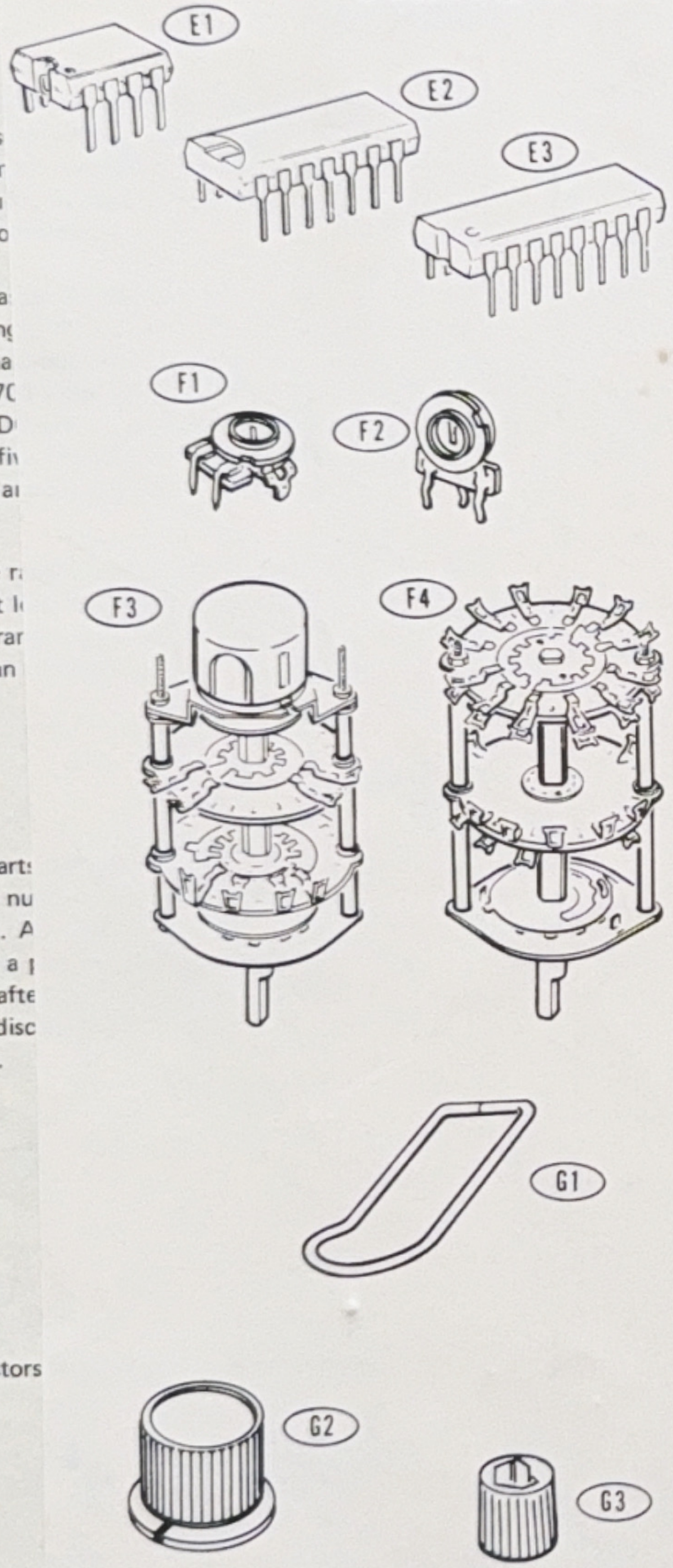
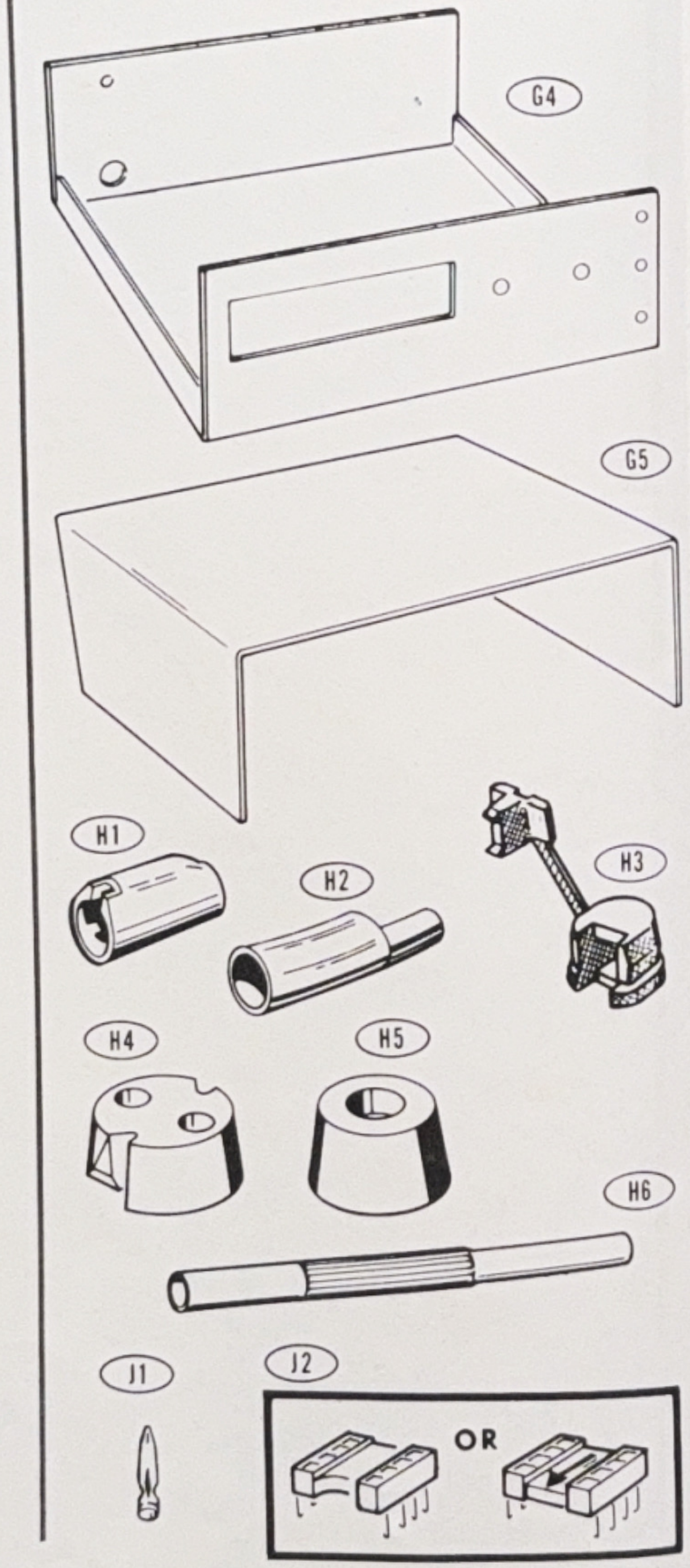
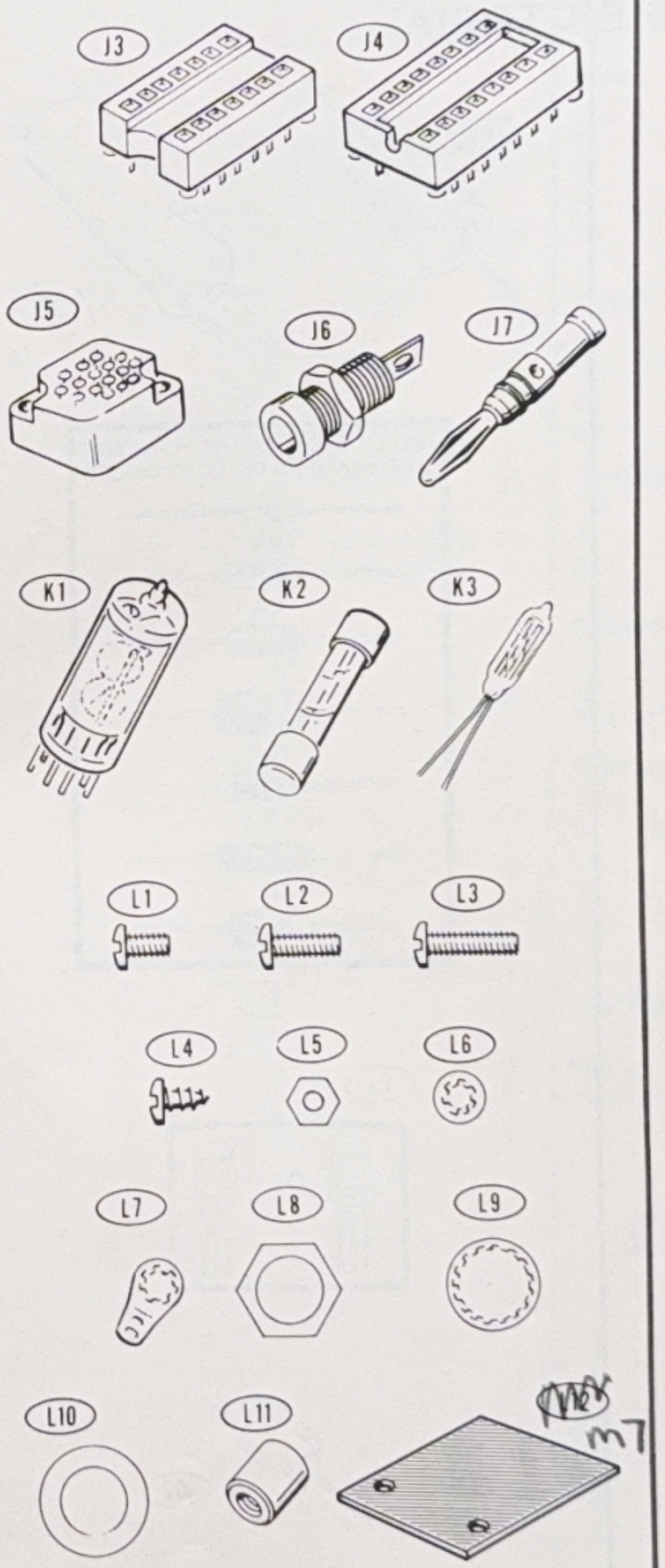
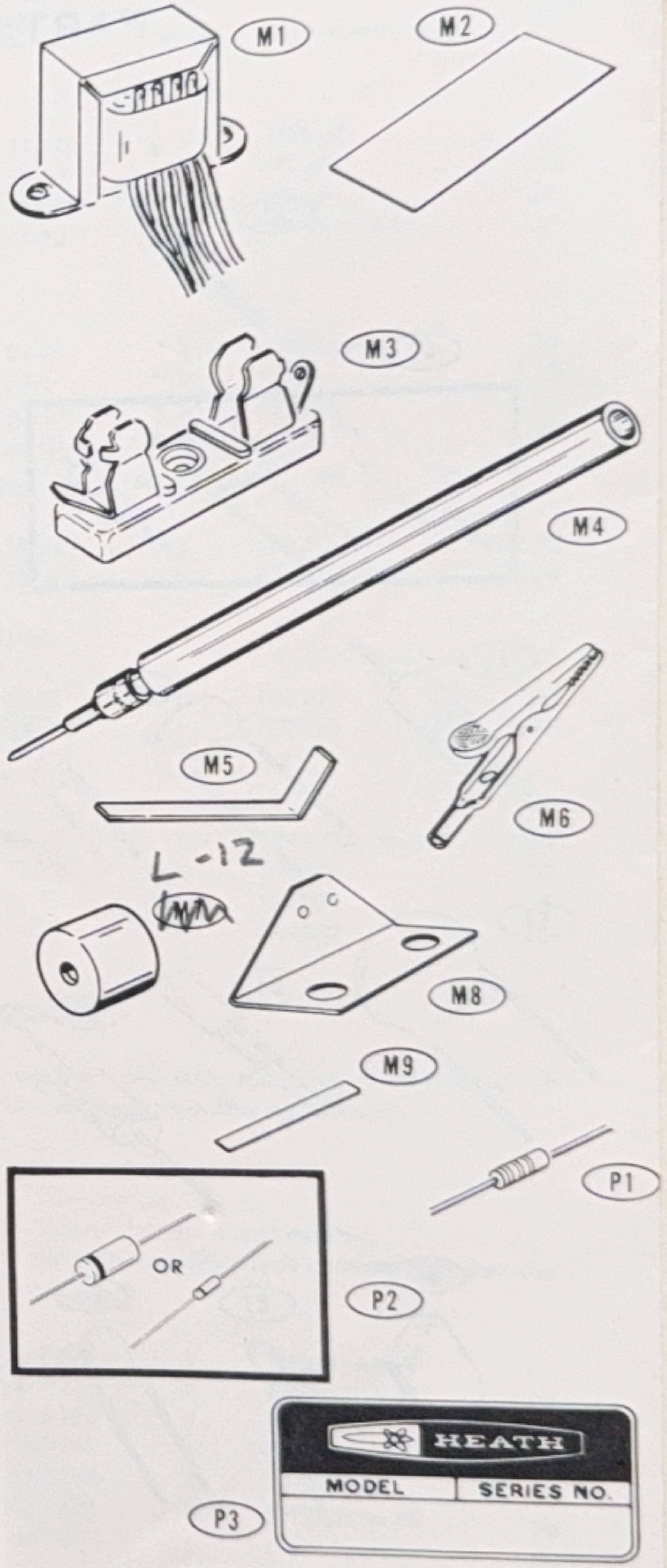
KEY No.	PART No.
RESISTORS	
1/2-Watt, 10%	
NOTE: 10% resistors	
•A1	1-18
A1	1-21
A1	1-102
A1	1-121
A1	1-34
A1	1-40

PARTS PICTORIAL (Cont'd.)









Resistors (cont'd.)

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
A1	1-109	2	12 kΩ (brown-red-orange)	.20
A1	1-162	2	18 kΩ (brown-gray-orange)	.15
A1	1-124	1	27 kΩ (red-violet-orange)	.15
A1	1-115	1	47 kΩ (yellow-violet-orange)	.15
A1	1-104	2	100 kΩ (brown-black-yellow)	.15
A1	1-185	1	180 kΩ (brown-gray-yellow)	.15
A1	1-87	2	330 kΩ (orange-orange-yellow)	.15
A1	1-101	5	1 MΩ (brown-black-green)	.15
A1	1-163	1	6.8 MΩ (blue-gray-green)	.15

PRECISION RESISTORS

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
A2	3-25-5	1	1 Ω, 5-watt, 1%	1.35
A2	2-47-1	1	10 Ω, .5%	1.00
A2	2-4	1	100 Ω, .5%	1.05
A2	2-83	1	200 Ω, 1%	1.00
A2	2-6	1	1000 Ω (1k), .5%	1.00
A2	2-670-12	1	1010 Ω (1.01 k), .5%	1.15
A2	2-228	1	2000 Ω, (2k), 1%	1.00
A2	2-17-12	1	9090 Ω (9.09 k), .1%	1.05
A2	2-38	1	20 kΩ, 1%	1.00
A2	2-294	1	90.9 kΩ, 5%	1.00
A2	2-54	1	200 kΩ, 1%	1.00
A2	2-98-1	1	909 kΩ, .5%	2.40
A2	2-55	1	2 MΩ, 1%	1.00

Other Resistor

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
A3	1-19-1	1	220 Ω, 10%, 1-watt (red-red-brown)	1.15

CAPACITORS

Mica

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
B1	20-52	1	7.5 pF	.55

Disc

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
B2	21-140	1	.001 µF	.15
B2	21-16	1	.01 µF	.15
B2	21-94	1	.05 µF	.25
B3	21-70	1	.01 µF, 1.4 kV	.25

Mylar*

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
B4	27-70	2	.0022 µF	.60
B5	27-1	2	.1 µF	2.35
B6	27-47	6	.1 µF	.30
B6	27-86	2	.47 µF	.95

Tantalum

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
B7	25-220	3	10 µF (10M)	.70
B8	25-223	2	47 µF (47M)	2.25

Electrolytic

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
B9	25-28	1	100 µF	.90
B10	25-148	1	1000 µF	1.45

DIODES

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
C1	56-25	2	1N4166A zener	1.50
C1	56-56	8	1N4149	.30
C1	57-27	3	1N2071	.75
C1	57-65	3	1N4002	.30

TRANSISTORS

NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways:

1. Part number.
2. Type number.
3. Part number and a type number.
4. Part number with a type number other than the one listed.

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
D1	417-234	3	2N3638A	.60
D1	417-134	4	MPS6520	1.05
D1	417-291	1	2N5458	1.10
D1	417-241	1	EL131	2.55
D1	417-294	2	MPSA42	.75
D1	417-801	4	MPSA20	.25
D2	417-272	1	D40C1	1.60

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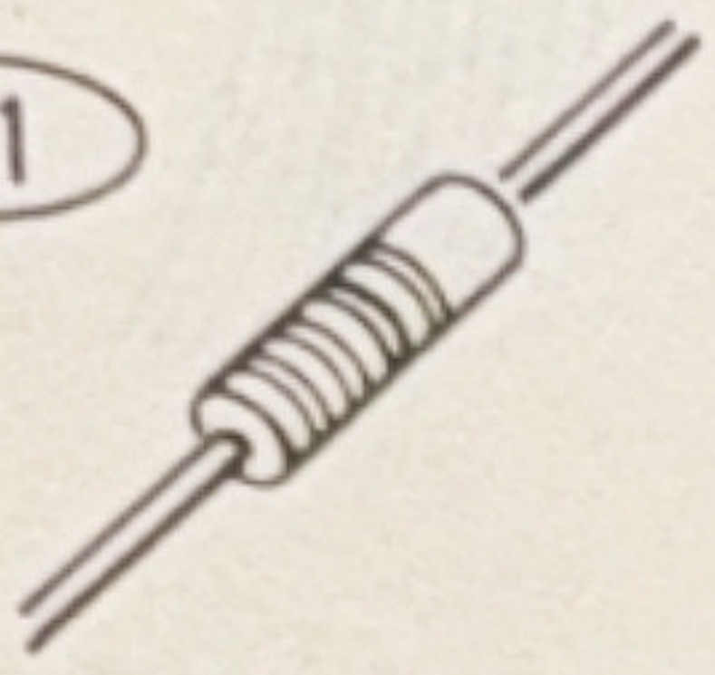
*DuPont Registered Trademark

PARTS PICTORIAL

A1



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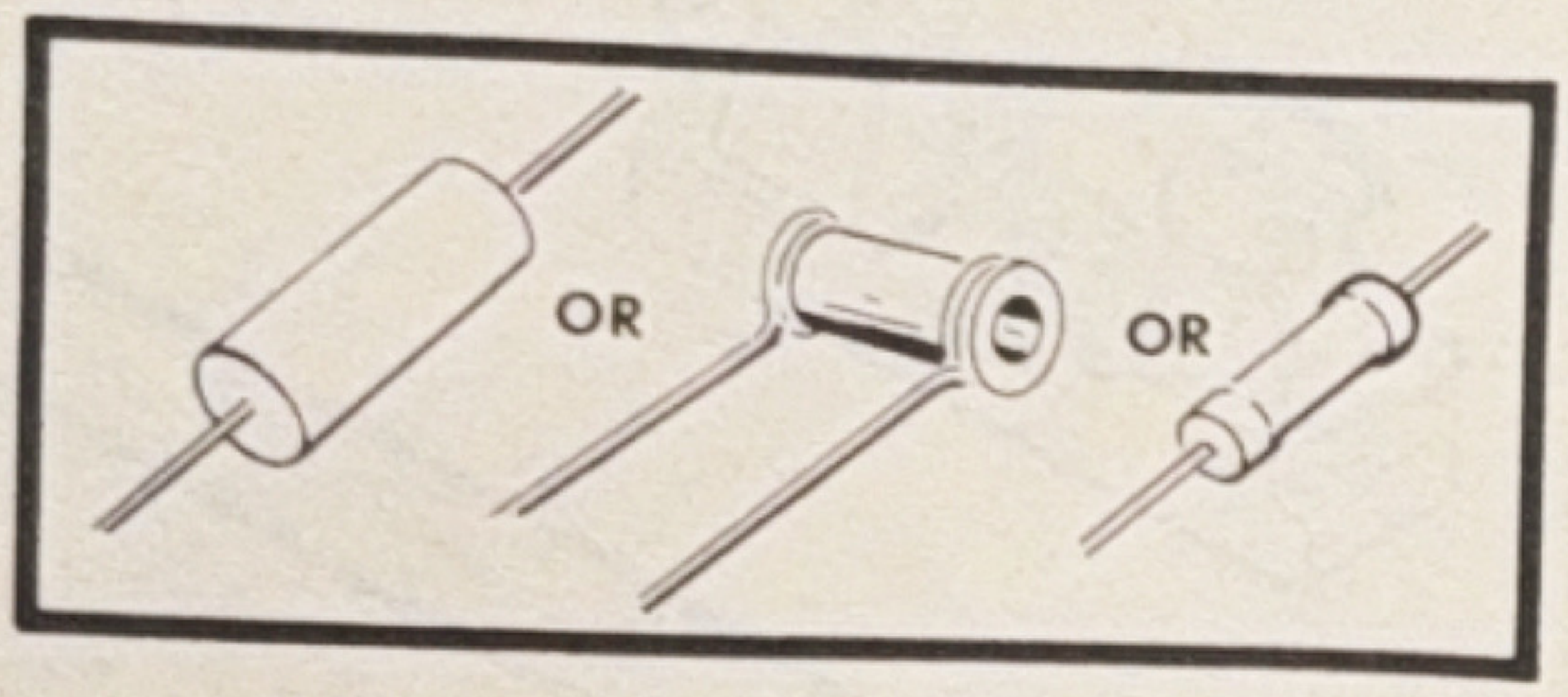

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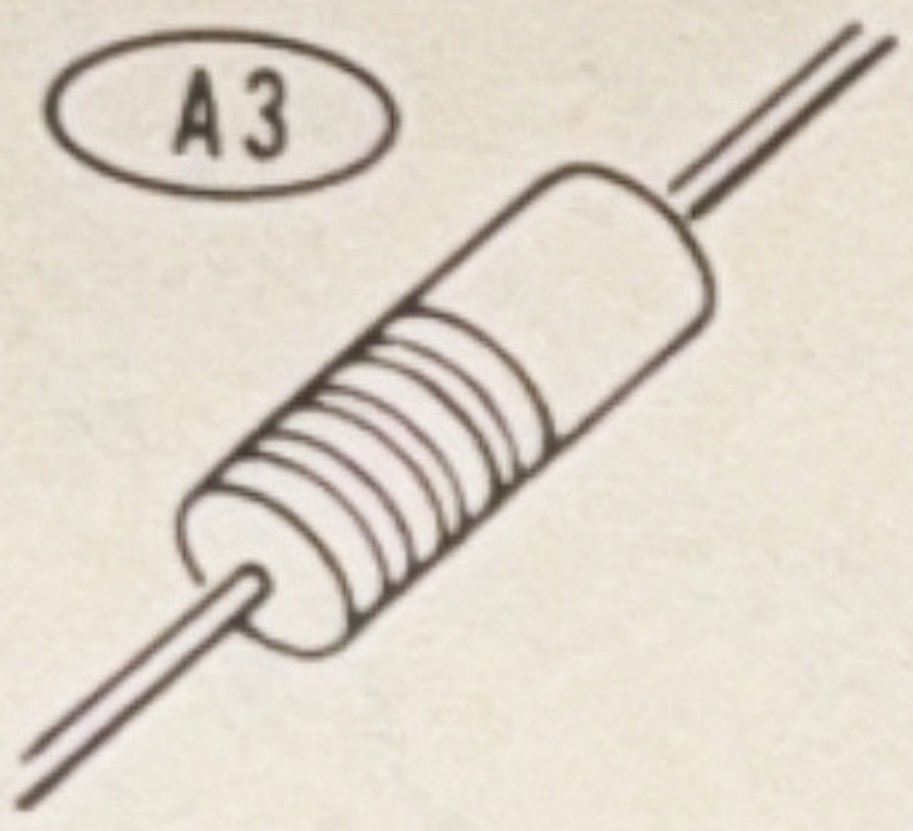

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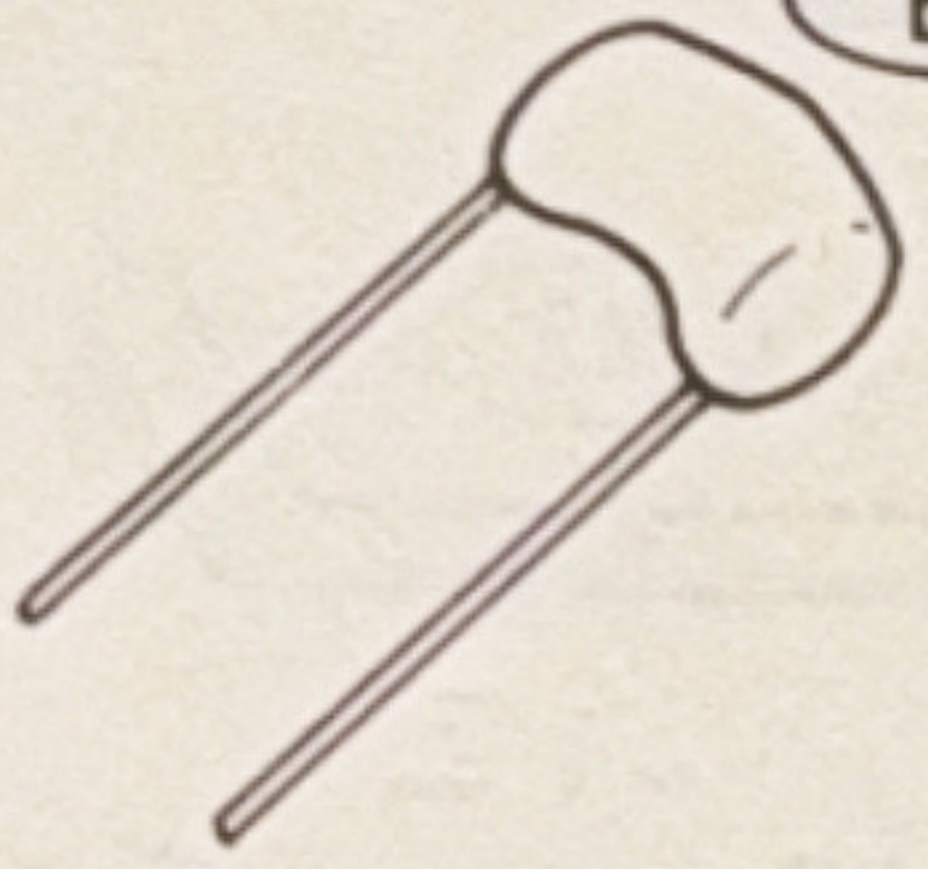

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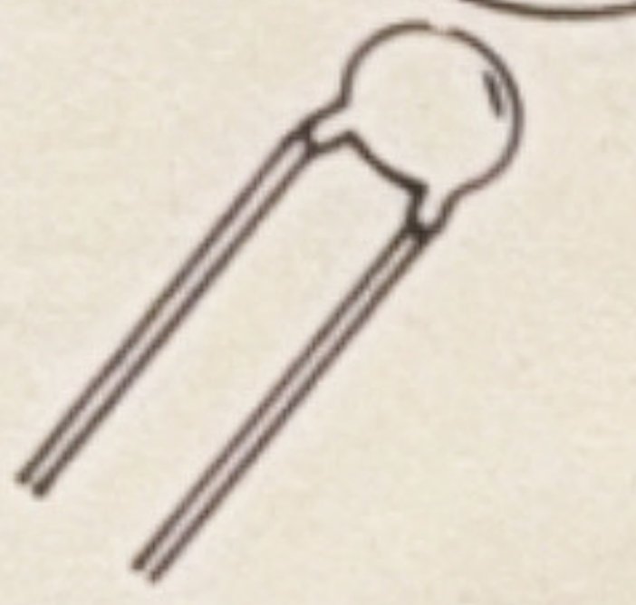

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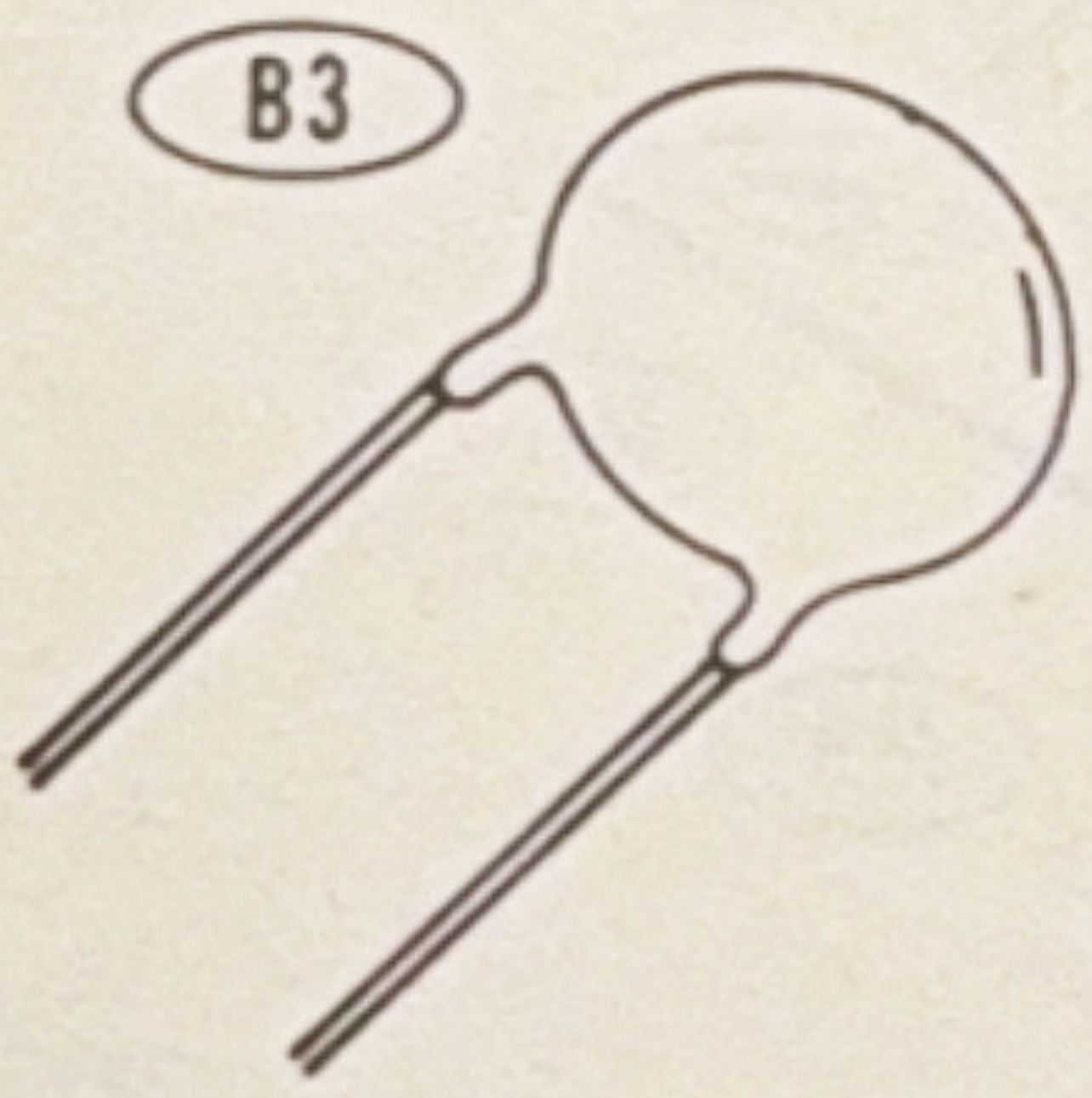

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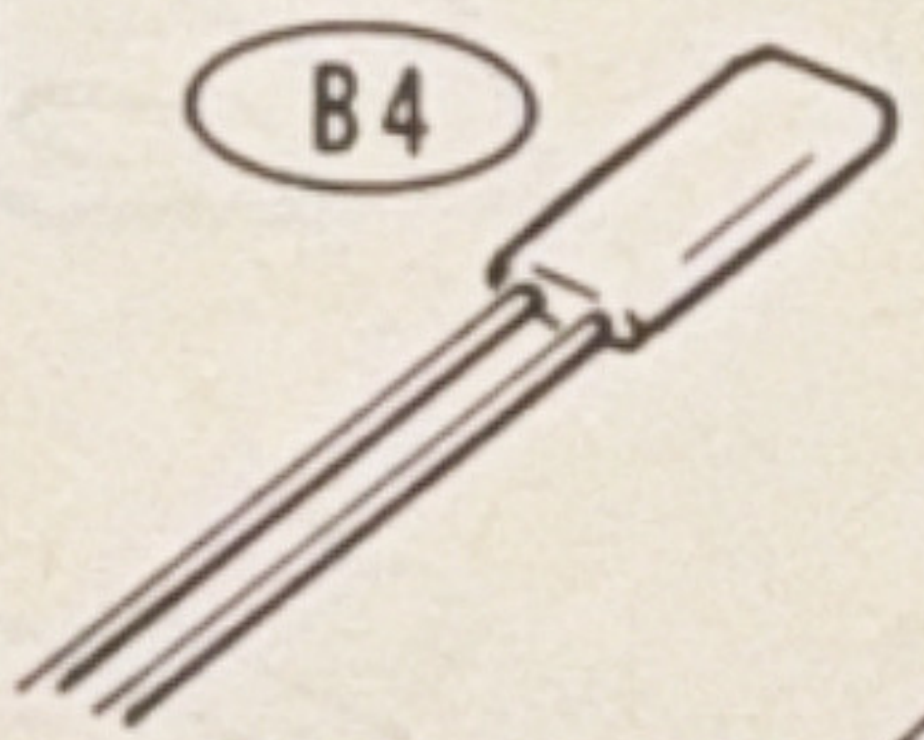

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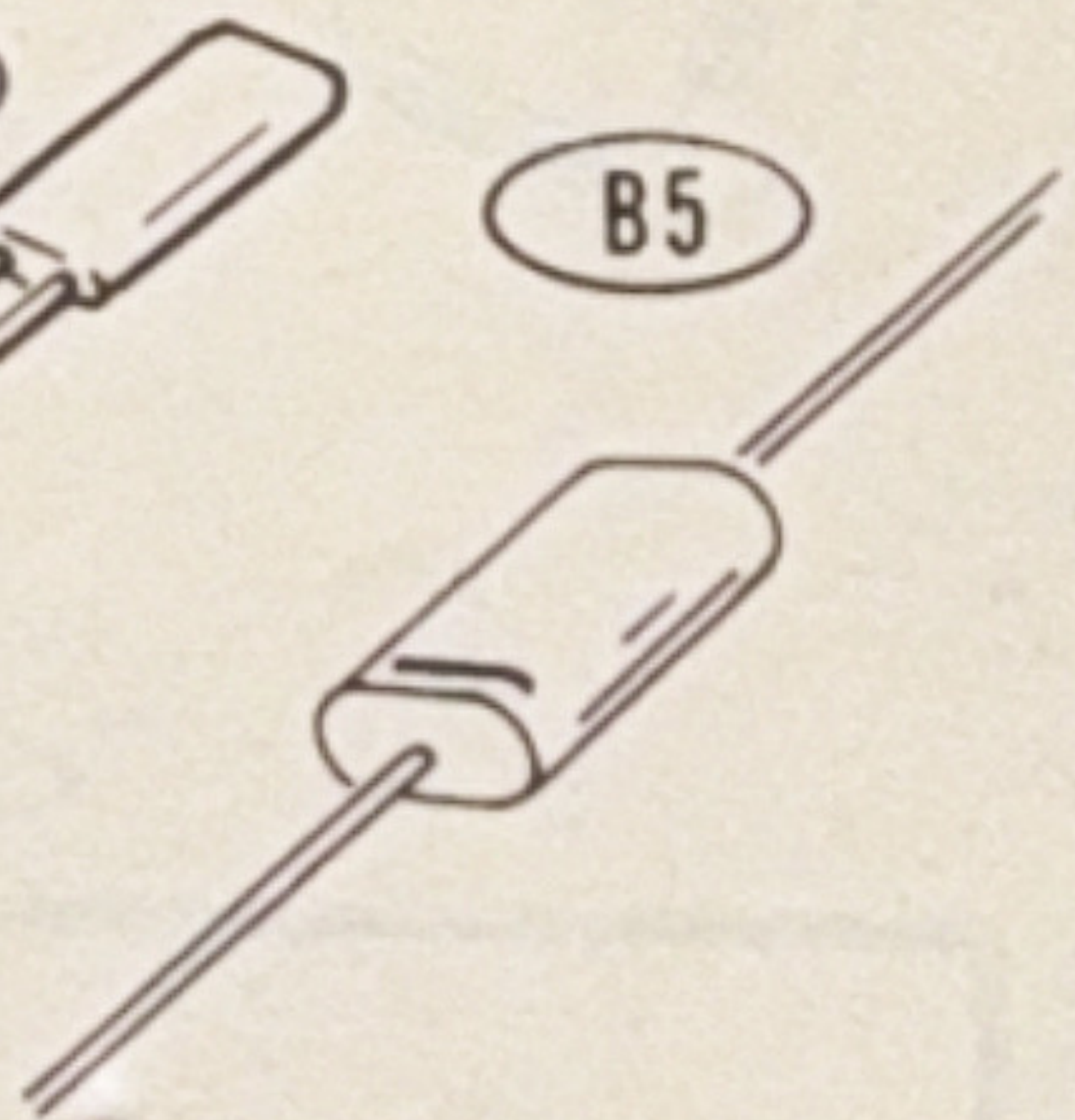
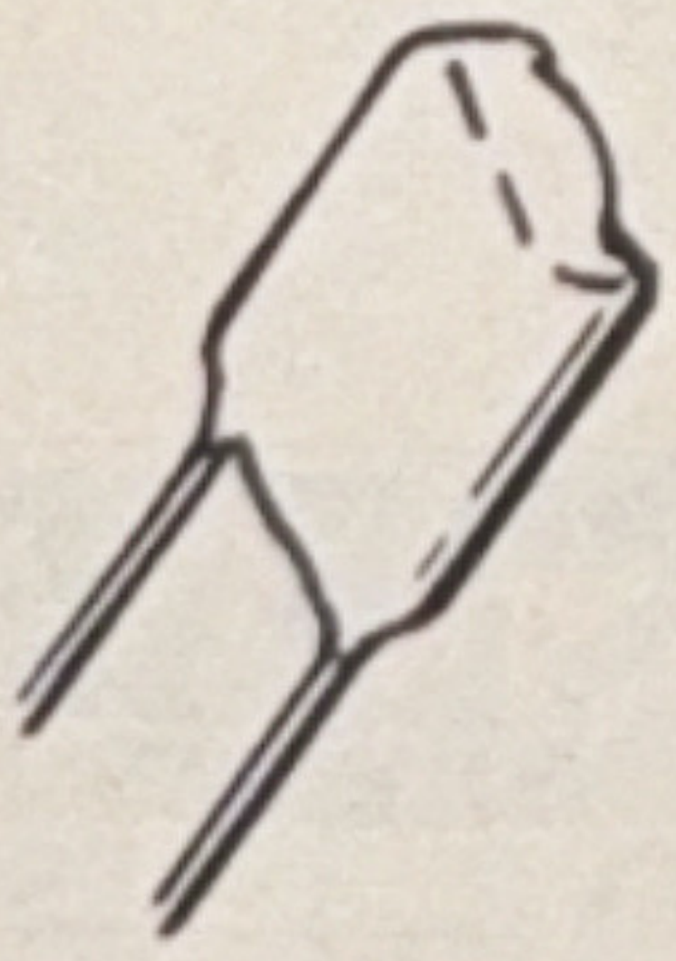
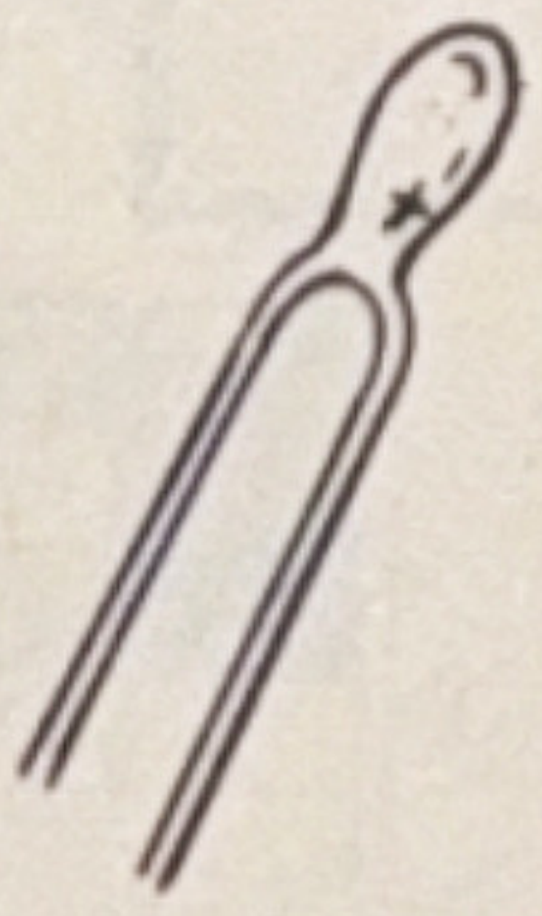


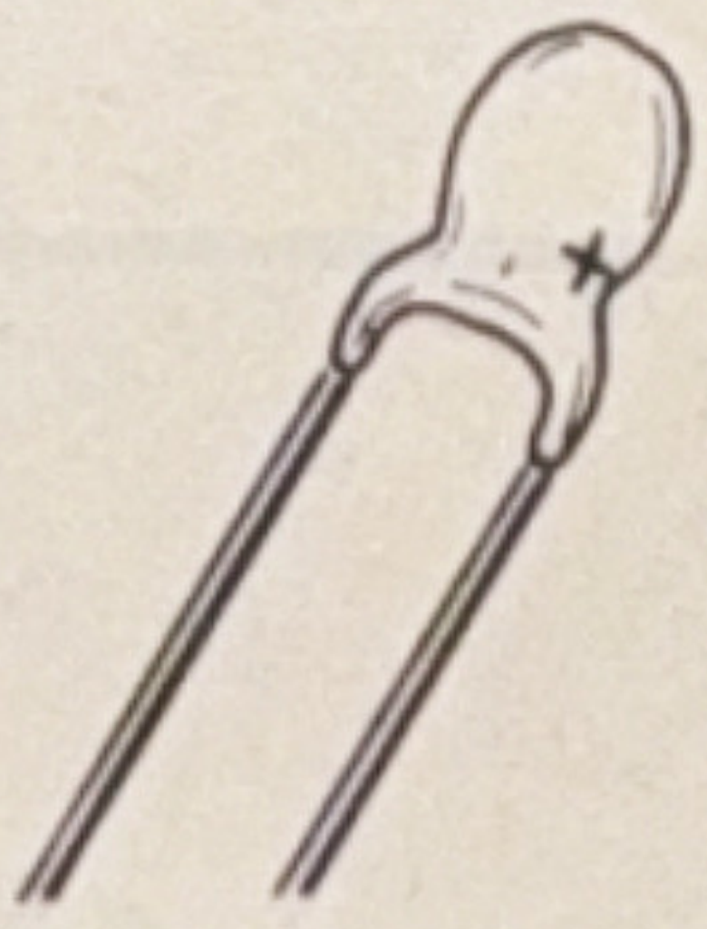
B6



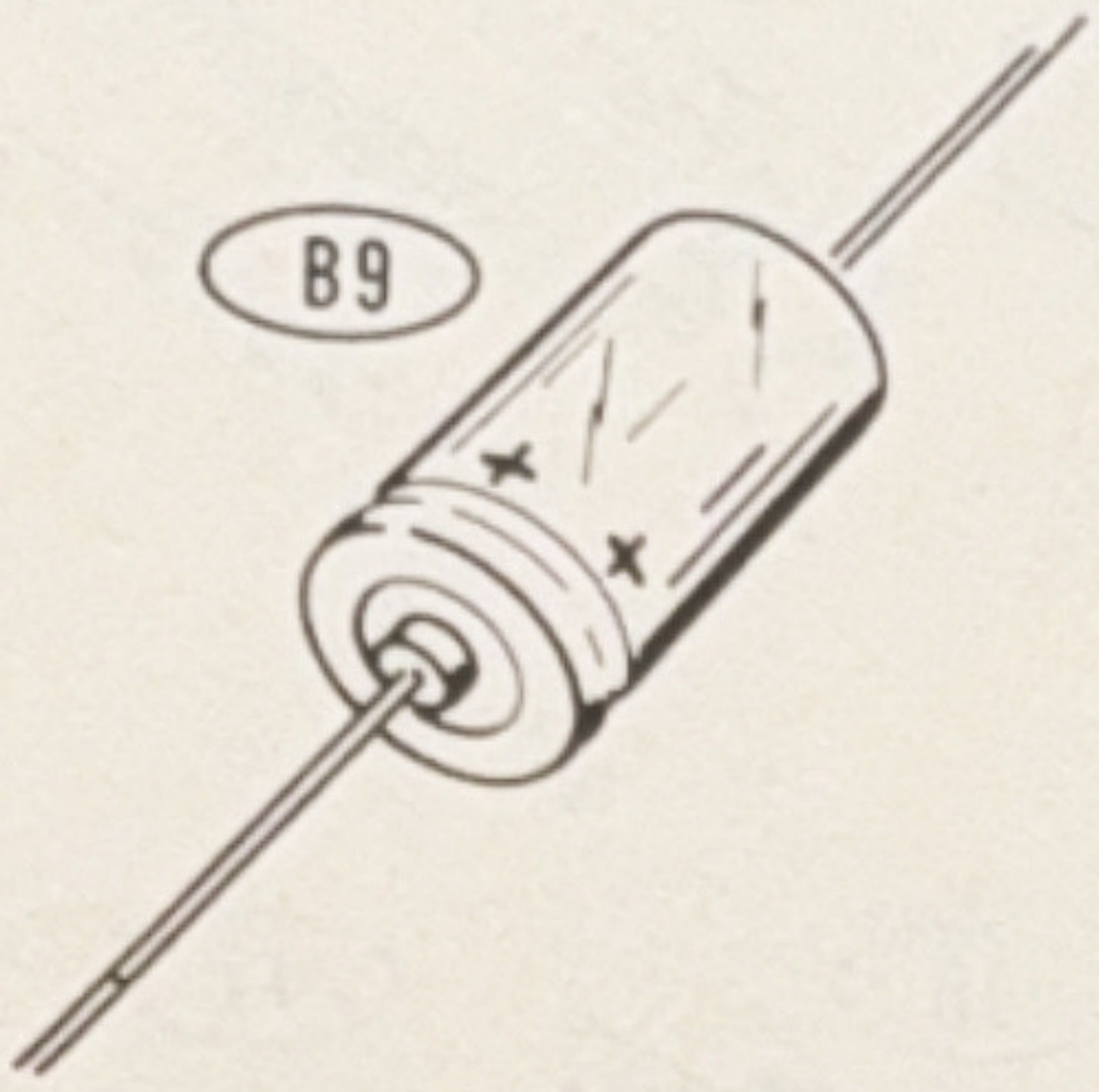
B7



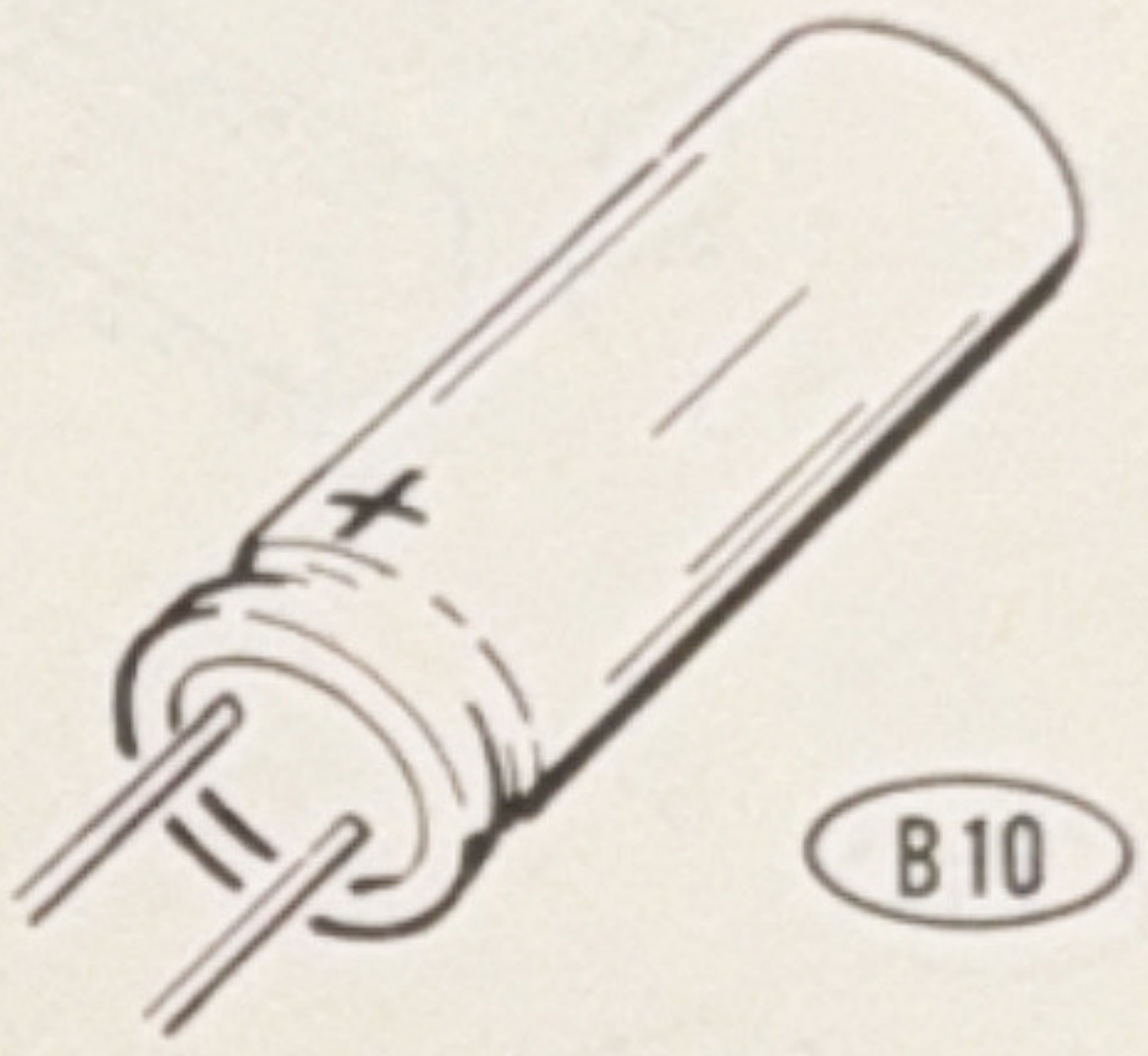
B8

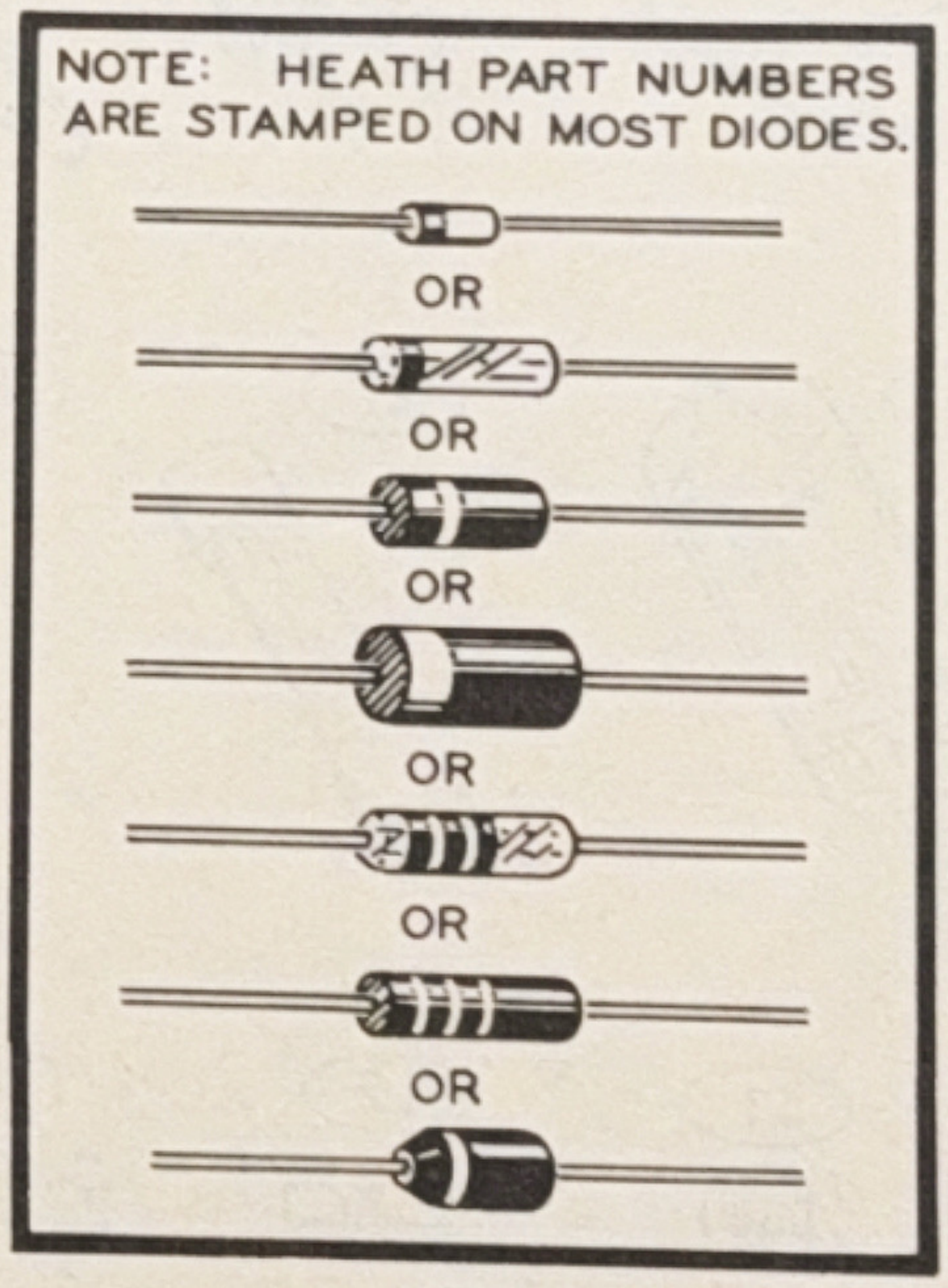


B9



B10

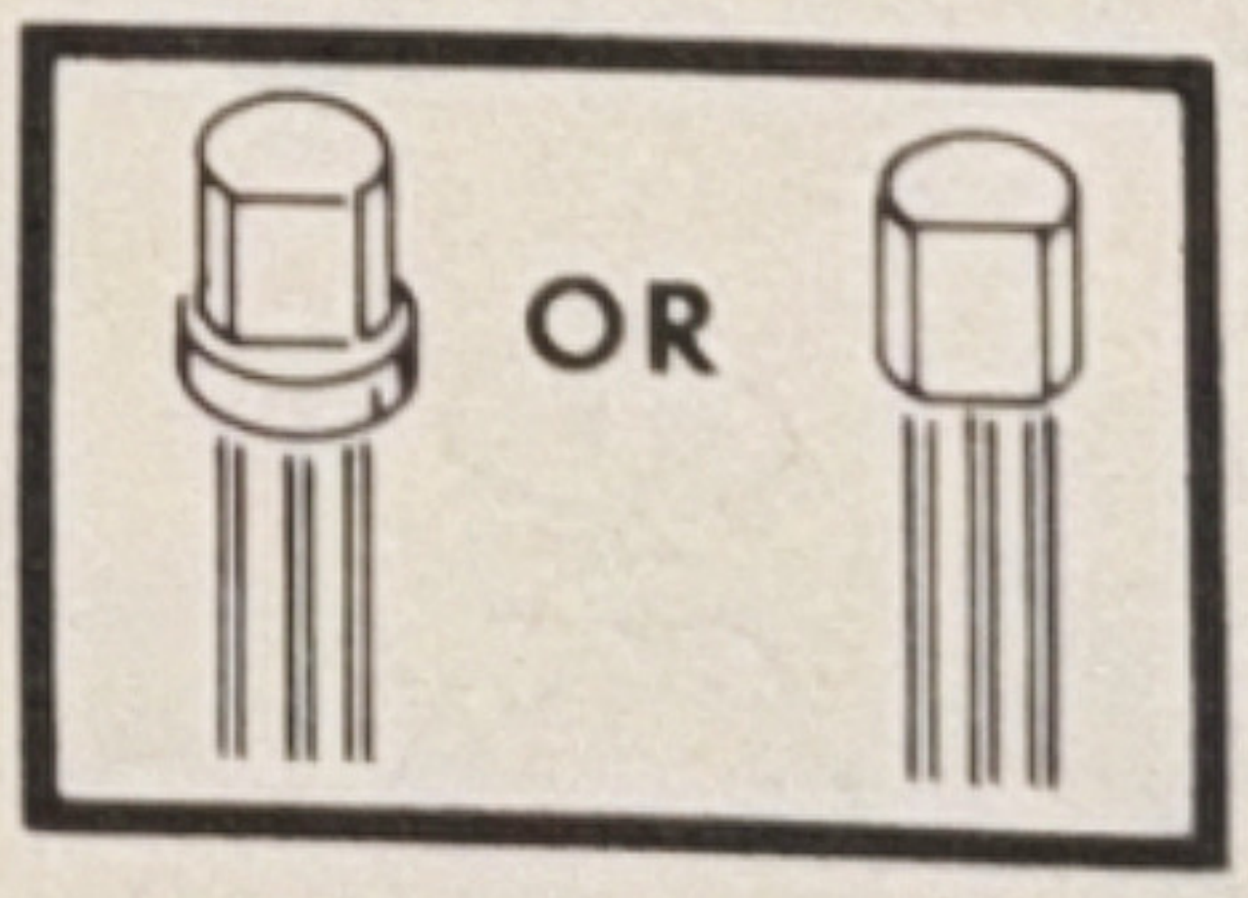


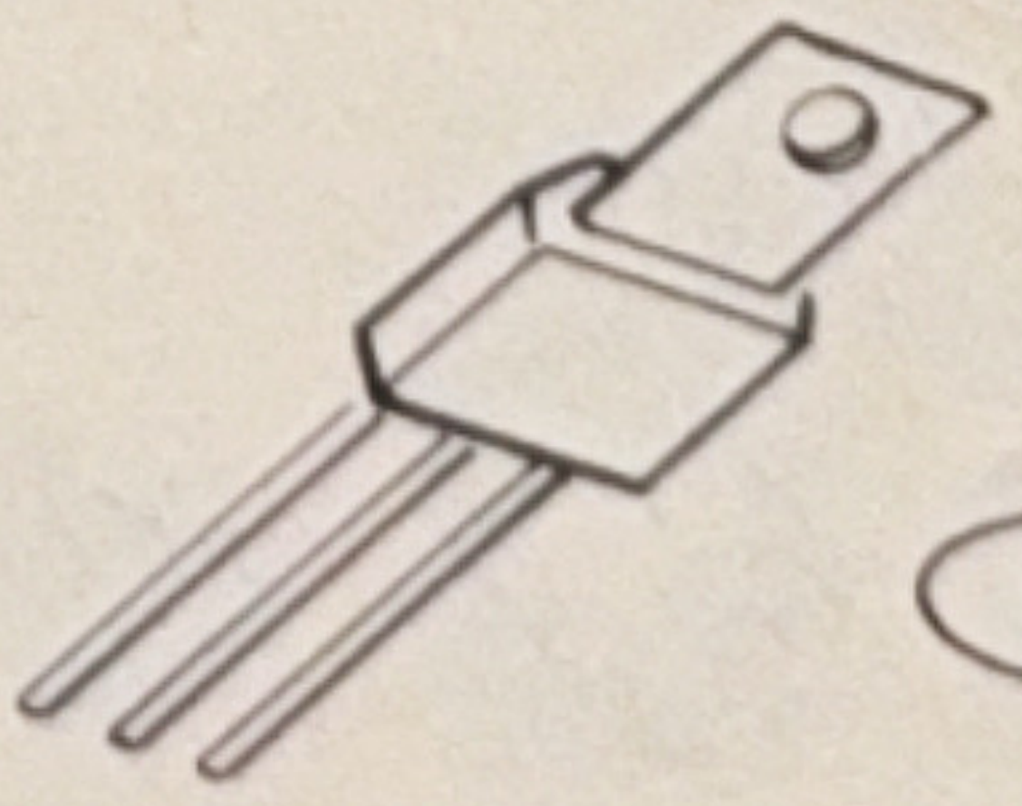


NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES.

C1

D1





D2

INTEGRATED CIRCUITS (IC's)

NOTE: If either the part number or the "Description" number is on an integrated circuit, you have the correct part. Do not be concerned about any other numbers. [The description number may have additional letters or numbers other than given in the list. Example: SN(7490)N or MC(7490)P.]

PLASTIC PARTS

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
E1	442-39	1	301A, 8-pin IC	2.35
E2	443-1	1	7400, 14-pin IC	.70
E2	443-5	1	7473, 14-pin IC	1.45
E2	443-7	2	7490, 14-pin IC	2.95
E2	443-46	1	7402, 14-pin IC	.85
E3	443-35	2	7441, 16-pin IC	4.30

CONTROLS-SWITCHES

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
F1	10-382	3	2000 Ω (2k)	1.00
F1	10-383	1	10 kΩ	1.00
F1	10-388	1	20 kΩ	1.00
F1	10-389	2	100 kΩ control	1.00
F1	10-384	1	500 kΩ control	1.00
F1	10-393	1	5 MΩ control	1.00
F2	10-1009	1	15 kΩ control	1.00
F3	63-698	1	6-position rotary switch	5.50
F4	63-699	1	5-position rotary switch	6.90

CABINET AND CHASSIS PARTS

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
G1	266-846	2	Foot ring	.75
G2	462-264	2	Knob	.75
G3	455-50	2	Knob insert	.15
G4	200-674-3	1	Chassis	5.85
G5	90-1105-3	1	Cabinet	4.90

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
H1	70-10	1	Black sleeve	.25
H1	70-11	1	Red sleeve	.25
H2	73-21	1	Alligator clip insulator	.15
H3	75-71	1	Line cord strain relief	.15
H4	261-35	2	Large foot	.20
H5	261-36	2	Small foot	.15
H6	490-5	1	Nut starter	.15

CONNECTOR-SOCKETS-JACKS-PLUG

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
J1	432-134	9	Wire connector (2 extra)	.15
J2	434-233	1	8-pin IC socket	.20
J3	434-225	5	14-pin IC socket	.25
J4	434-226	2	16-pin IC socket	.25
J5	434-234	2	Tube socket	1.05
J6	436-11	1	Red jack	.20
J6	436-22	1	Black jack	.20
J6	436-24	1	White jack	.20
J7	438-47	2	Input plug	.20

TUBES-FUSES-LAMPS

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
K1	411-284	2	Display tube	5.40
K2	421-2	1	3-ampere fuse	.15
K2	421-49	1	1/8-ampere fuse	.25
K3	412-63	2	NE211 neon lamp	1.15

HARDWARE

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
L1	250-56	11	6-32 x 1/4″ screw	.05
L2	250-89	4	6-32 x 3/8″ screw	.05
L3	250-162	6	6-32 x 1/2″ screw	.05
L4	250-369	4	#6 x 1/4″ sheet metal screw	.05
L5	252-3	11	6-32 nut	.05
L6	254-1	17	#6 lockwasher	.05
L7	259-1	1	#6 solder lug	.05
L8	252-7	2	Control nut	.05
L9	254-4	2	Control lockwasher	.05
L10	253-10	2	Control flat washer	.05
L11	255-103	3	6-32 x 5/16″ spacer	.10
L12	255-713	2	6-32 x 1/2″ spacer	.35

LINE CORD-TEST LEADS-WIRE-SLEEVING

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
	89-23	1	Line cord	1.25
	340-8	33"	Small bare wire	.05
	340-11	6"	Large bare wire	.10
	341-1	48"	Black test lead	.10
	341-2	48"	Red test lead	.10
	344-21	30"	Red stranded wire	.05/ft
	344-50	8-1/2"	Black wire	.05/ft
	344-51	8-1/2"	Brown wire	.05/ft
	344-52	18"	Red wire	.05/ft
	344-54	22"	Yellow wire	.05/ft
	344-55	9"	Green wire	.05/ft
	344-56	15"	Blue wire	.05/ft
	344-59	36"	White wire	.05/ft
	346-1	6"	Sleeving	.10/ft

MISCELLANEOUS

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
M1	54-866	1	Power transformer	6.60
M2	75-109	1	Large fiber insulator	.25
	85-1595-1	1	Printed circuit board	7.55
M3	422-1	2	Fuseholder	.40
M4	439-1	1	Test probe	.70
M5	490-111	1	IC puller	.15
M6	260-1	1	Alligator clip	.10
M7	75-716	1	Small lamp insulator	.15
M8	204-1965	1	Switch mounting bracket	.55
M9	205-778	1	Alignment tool blade	.15
			Solder (NOTE: Additional 3' rolls of solder, #331-6, can be ordered for 25 cents each.)	

Miscellaneous (cont'd.)

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
	100-1612	1	Calibration envelope	1.15
			containing:	
P1		1	10 kΩ, 1/4-watt, 5% resistor (brown-black-orange)	
P1		1	22 kΩ, 1/4-watt, 5% resistor (red-red-orange)	
P2		1	1N709A zener diode	

PRINTED MATERIAL

NOTE: Be sure you refer to the numbers on the blue and white label in any communications you may have about this kit with Heath Company. You may want to write the model and series numbers in this sample for a future convenience.

KEY No.	PART No.	QTY.	DESCRIPTION	PRICE Each
P3	391-34	1	Blue and white label	.15
	390-362	1	Fuse label	
	597-260	1	Parts Order Form	
	597-308	1	Kit Builders Guide	
		1	Manual (See front cover for part number.)	

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when you order from a Heathkit Electronic Center to cover local sales tax, postage, and handling. Outside the U.S.A., parts and service will reflect additional transportation, taxes, duties, and rates of exchange.

STEP-BY-STEP ASSEMBLY

CIRCUIT BOARD

Resistors are designated by the color code and the resistance value. The symbol "Ω" means ohms (K = 1,000; M = 1,000,000). Capacitors are designated by their value and type. The symbol "μF" means microfarad, and "pF" means picofarad. 1 μF is equal to 1,000,000 pF.

Due to the small foil area around the circuit board holes and the small areas between foils, it is necessary to use the utmost care to prevent solder bridges between adjacent foil areas. Use a minimum amount of solder and do not heat components excessively. Diodes, transistors, and IC's can be damaged if subjected to excessive amount of heat.

NOTE: For soldering in difficult areas, proceed as follows: Be sure your soldering iron is cool. Then wrap the large bare wire supplied with this kit, tightly around the soldering iron tip as shown in Figure 1. Allow approximately 1/4" of wire to extend beyond the end of the soldering iron. Cut the wire end to a chisel shape as shown. Then turn the soldering iron on and melt a small amount of solder around the bare wire. This will improve heat transfer from the soldering iron tip to the wire. You may have to replace this arrangement occasionally, as a wire wrap will loosen after it has been heated for some time.

Parts will be installed on the top (the side with the component outlines) of the circuit board, and the leads will be soldered to the foil (other) side.

Only a portion of the circuit board is shown in each of the following Pictorials. A small drawing at the top of each Pictorial shows the area of the circuit board to be assembled.

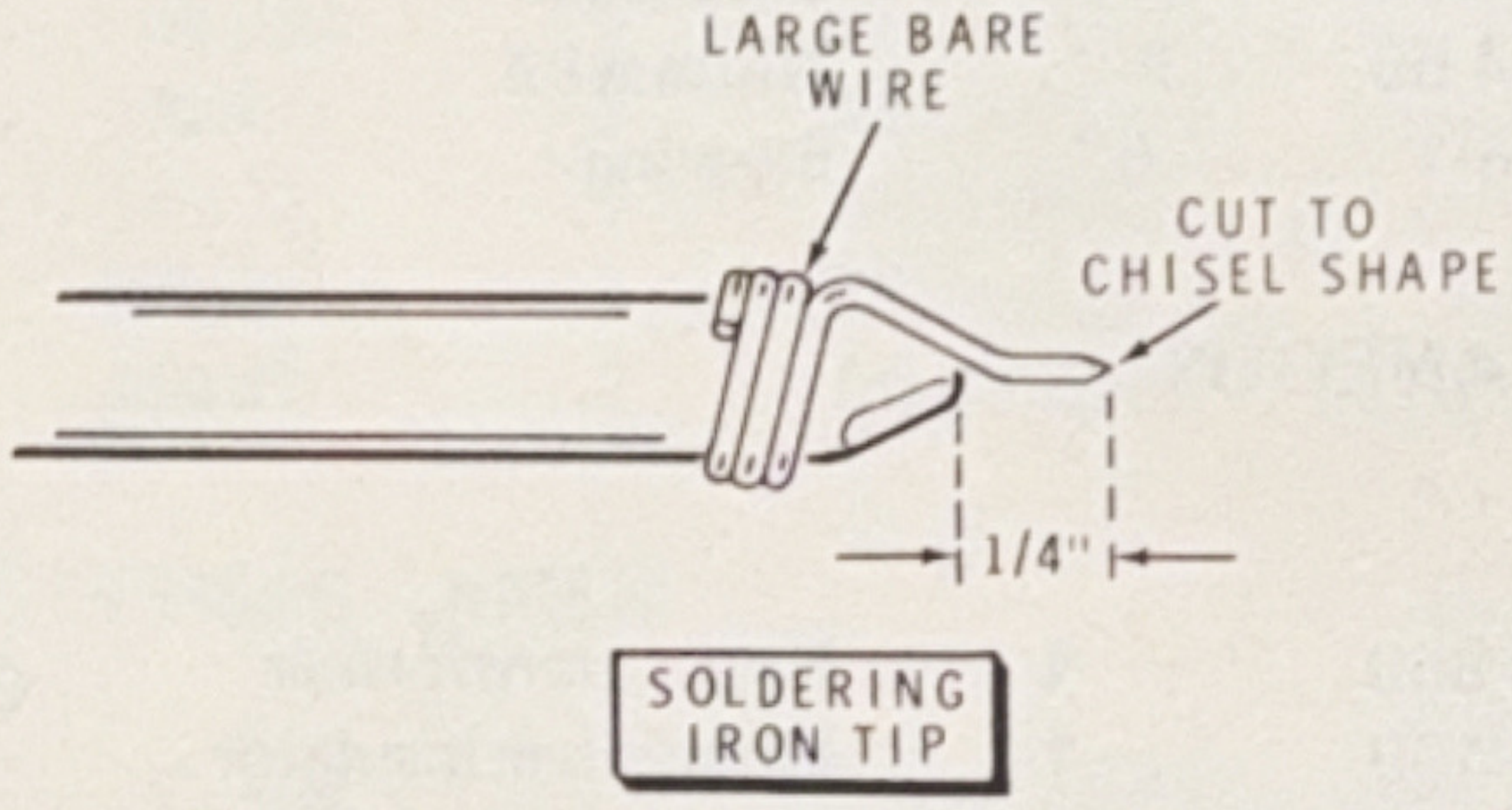


Figure 1

START

Position the circuit board printed side up. Then proceed with the following steps.

(•) 120 kΩ (brown-red-yellow).

(•) 1000 Ω, 5% (brown-black-red-gold).

(•) 82 kΩ (gray-red-orange).

(•) 82 kΩ (gray-red-orange).

(•) 100 kΩ, 5% (brown-black-yellow-gold).

(•) 18 kΩ, 5% (brown-gray-orange-gold).

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN.

WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.

SAFETY WARNING: Avoid eye injury when you clip off excess leads. We suggest that you wear glasses, or at least clip the leads so the ends will not fly toward your eyes.

(•) Solder the leads to the foil and cut off the excess lead lengths.

NOTE: Use the small bare wire to make jumper wires. Cut each one to the length specified in the step.

(•) 1-1/4" jumper wire.

(•) 10 MΩ (brown-black-blue). Bend one lead of the resistor as shown in the Pictorial before you install the resistor.

(•) Place a 1/2" length of sleeving on a 1-1/4" jumper wire. Then install the jumper wire as shown.

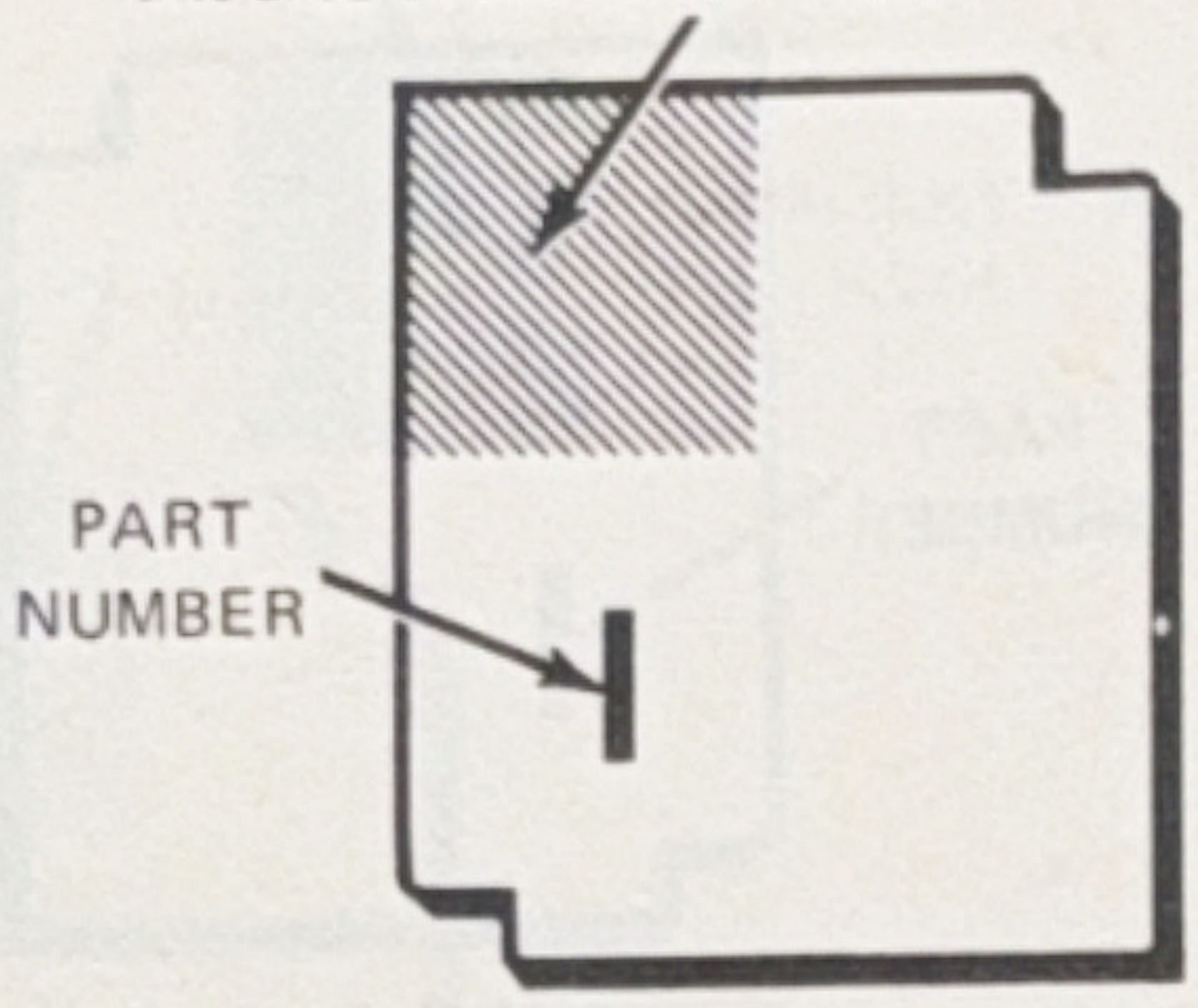
(•) 10 MΩ (brown-black-blue).

(•) 18 kΩ, 5% (brown-gray-orange-gold).

(•) 1-1/4" jumper wire.

(•) 1-1/4" jumper wire.

(•) Solder the leads to the foil and cut off the excess lead lengths.


The steps performed in this Pictorial are in this area of the circuit board.
PART NUMBER

IDENTIFICATION DRAWING

CONTINUE

(•) 1000 Ω, 5% (brown-black-red-gold).

(•) 1-1/4" jumper wire.

(•) 120 kΩ (brown-red-yellow).

(•) 1000 Ω, 5% (brown-black-red-gold).

(•) 1" jumper wire.

(•) 2-1/4" jumper wire

(•) 2" jumper wire.

(•) 1-1/4" jumper wire.

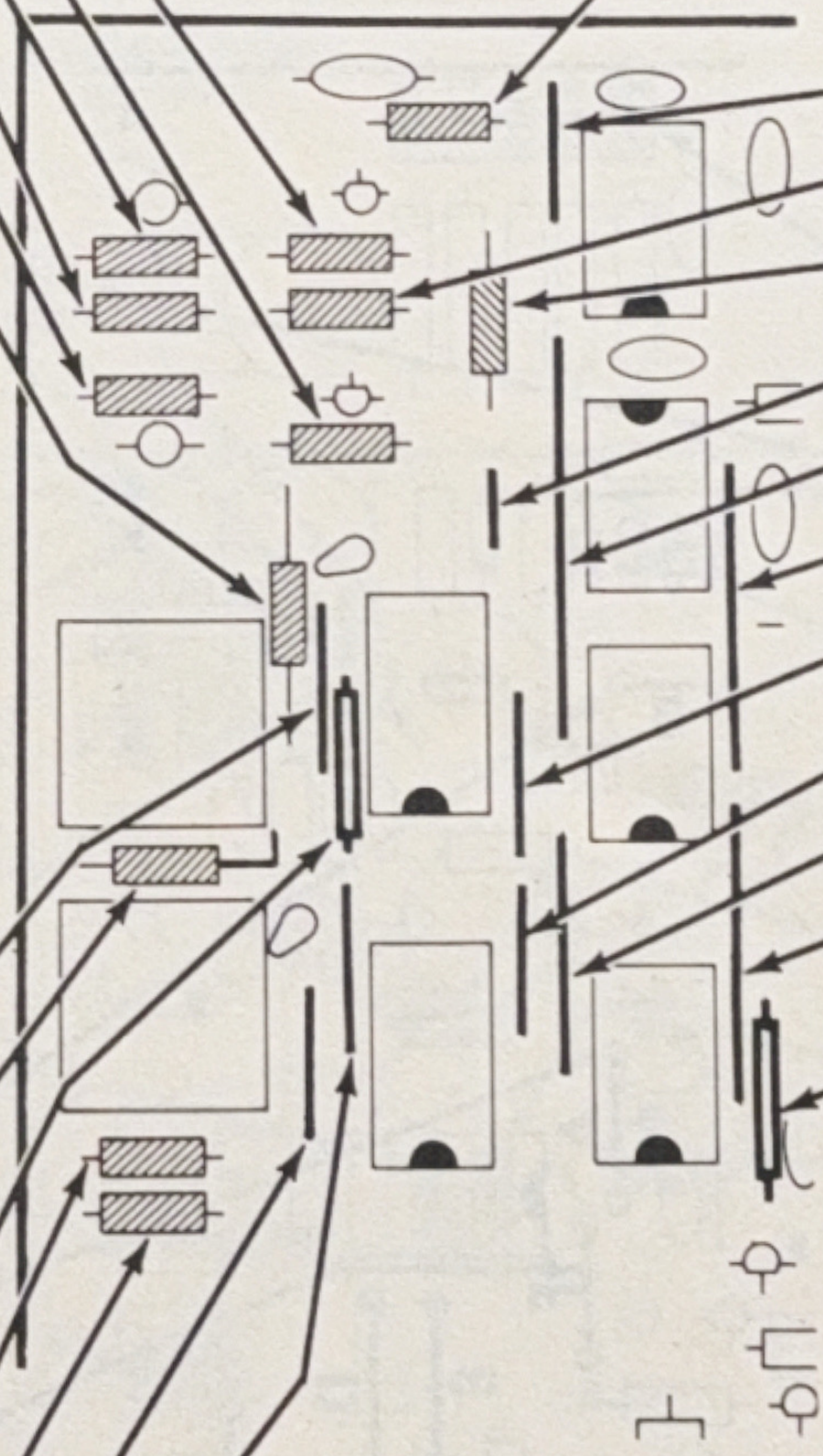
(•) 1-1/4" jumper wire.

(•) 1-1/2" jumper wire

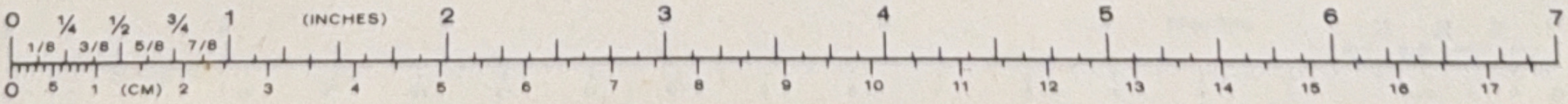
(•) 2" jumper wire.

(•) Place a 1/2" length of sleeving on a 1-1/2" jumper wire. Then install the jumper wire as shown.

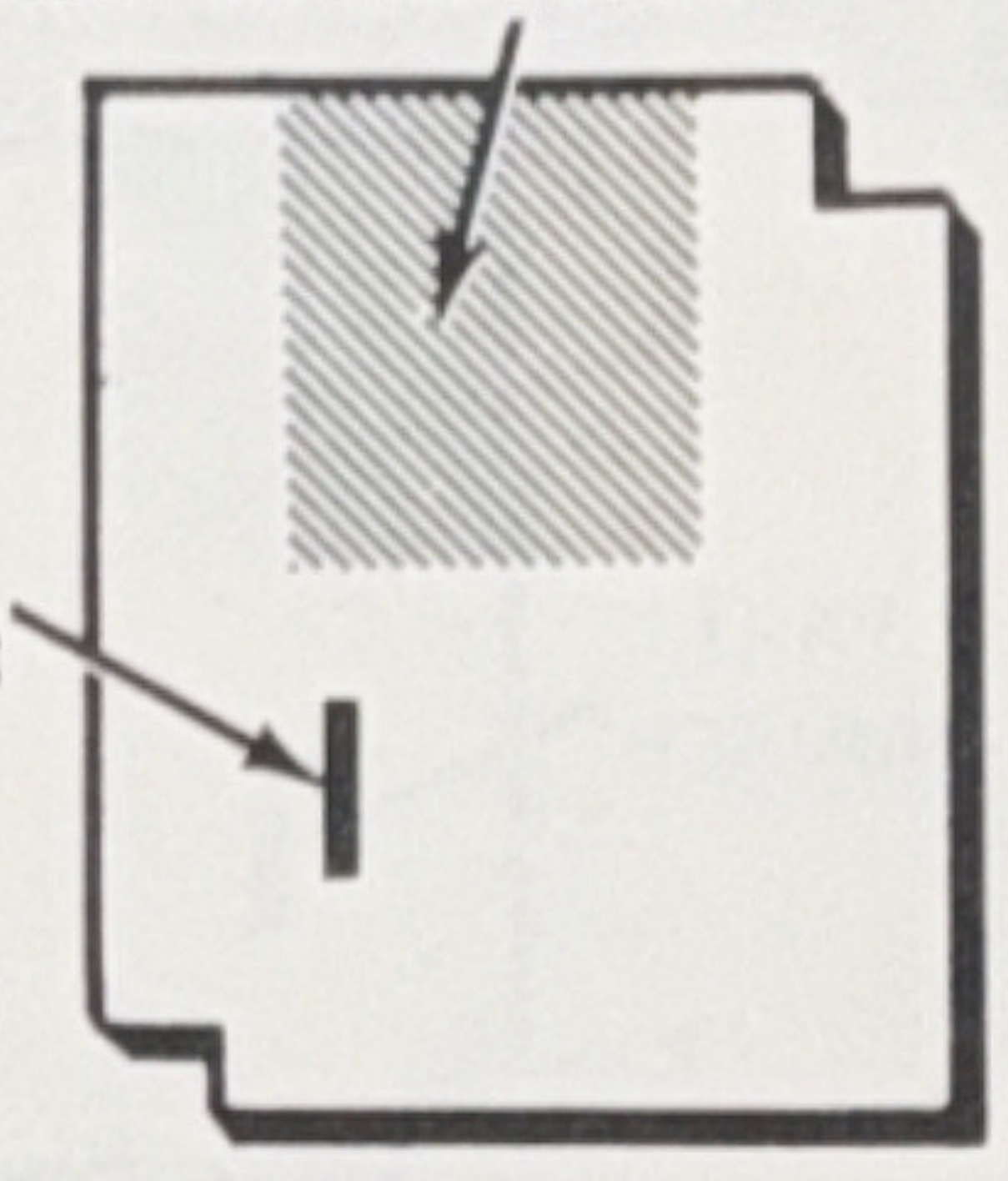
(•) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-1



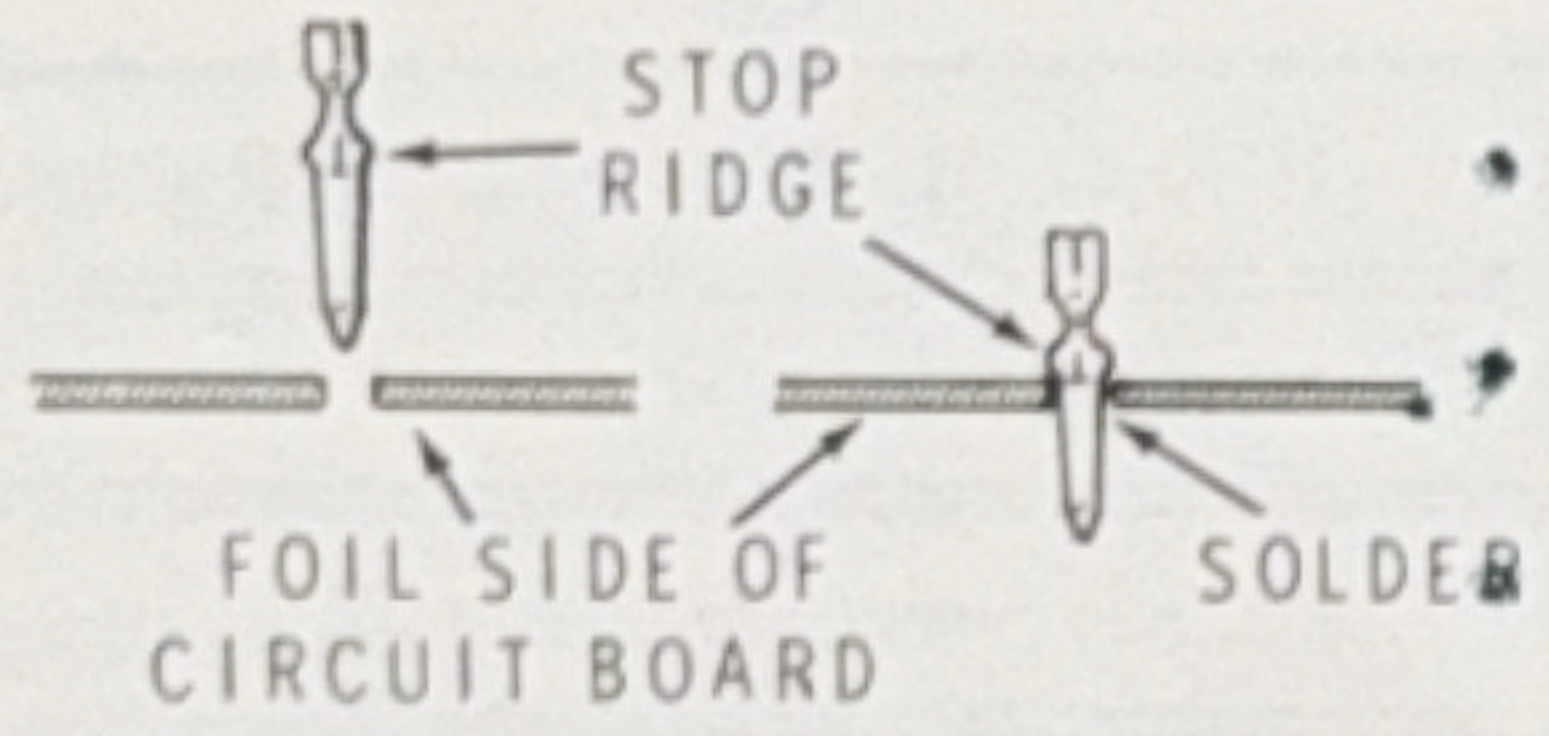
The steps performed in this Pictorial are in this area of the circuit board.



IDENTIFICATION DRAWING

START

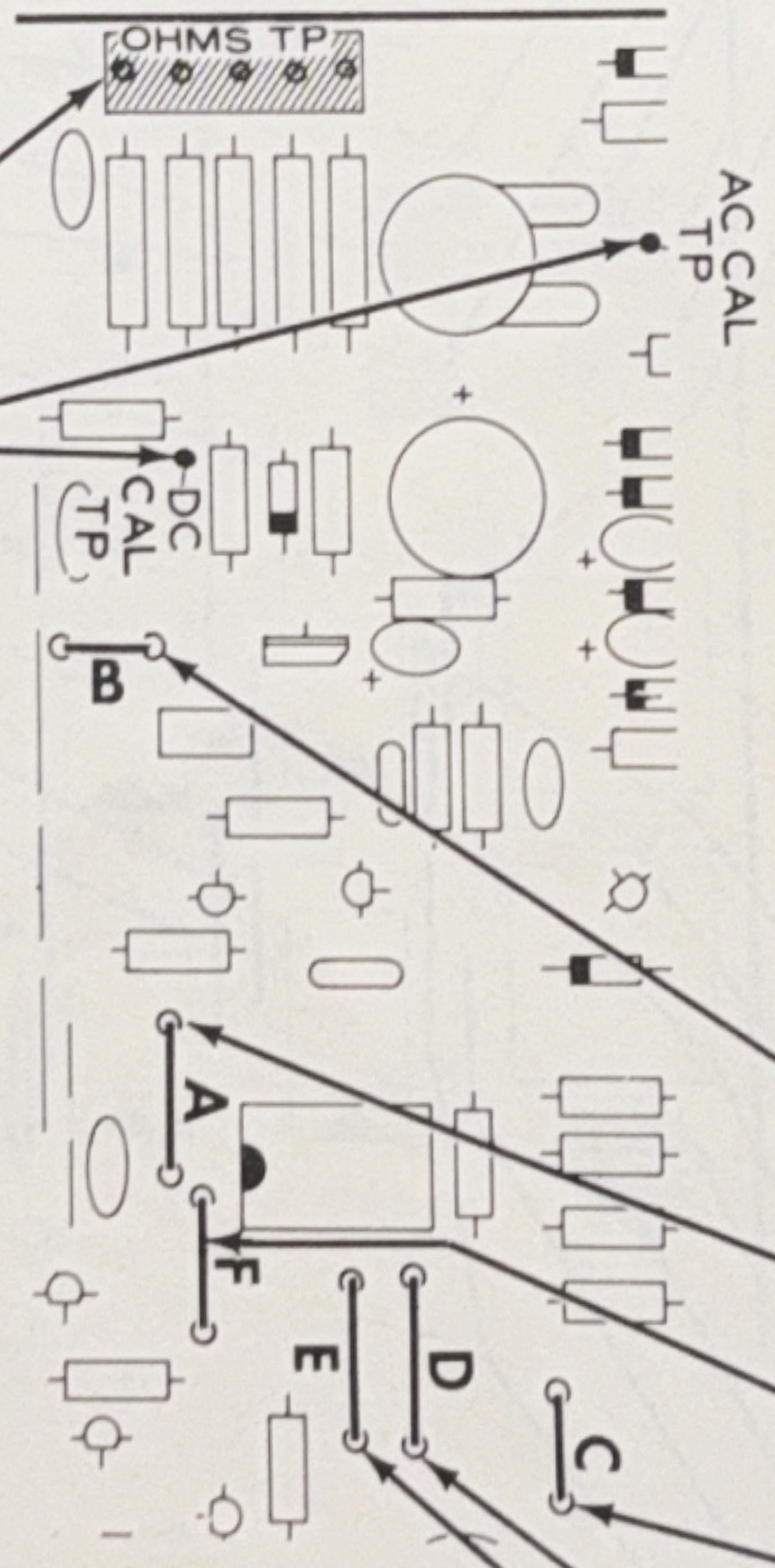
NOTE: Install wire connectors in the following steps as shown. Solder each connector to the foil as you install it.



( ) Five wire connectors within the outline marked "OHMS TP".

( ) One wire connector at the hole marked "AC CAL TP".

( ) One wire connector at the hole marked "DC CAL TP".



CONTINUE

( ) 7/8" jumper wire at B.

( ) 7/8" jumper wire at A.

( ) 7/8" jumper wire at F.

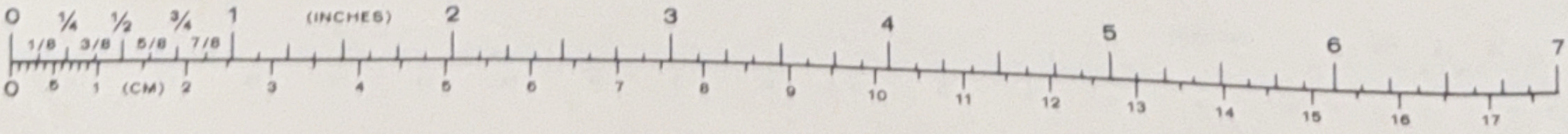
( ) 7/8" jumper wire at C.

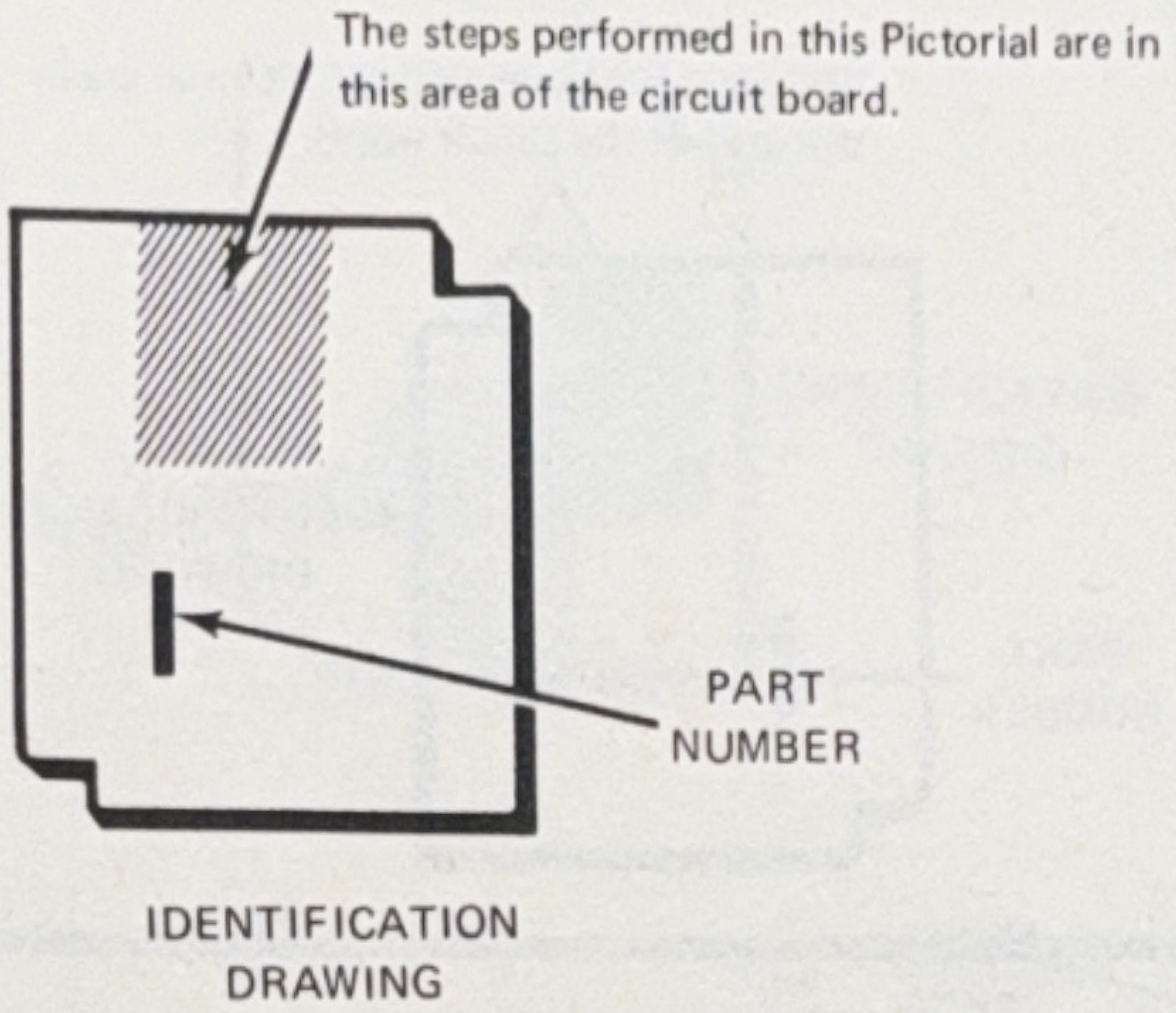
( ) 1-1/8" jumper wire at D.

( ) 1-1/8" jumper wire at E.

( ) Solder the leads to the foil and cut off the excess lead lengths.

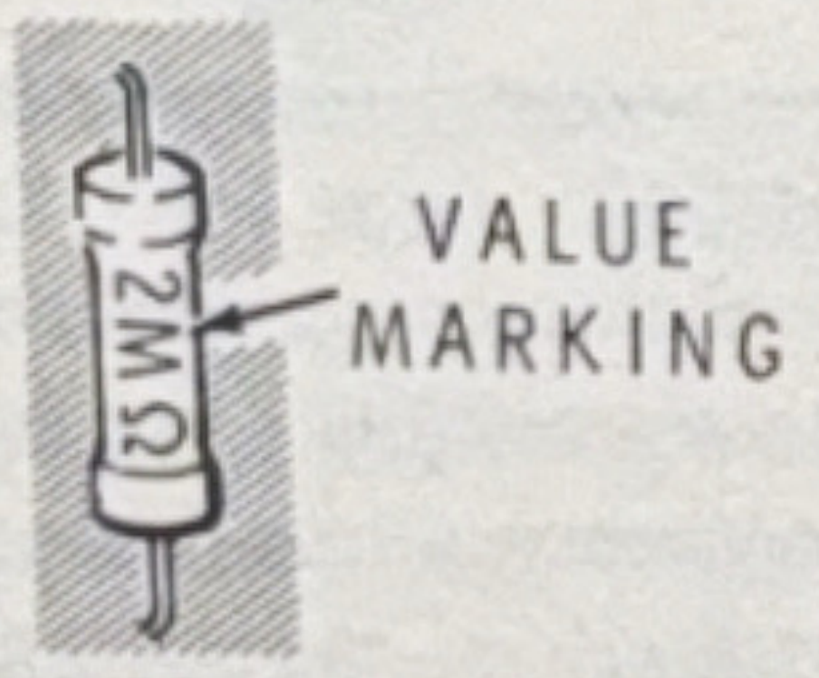
PICTORIAL 1-2




The steps performed in this Pictorial are in this area of the circuit board.
PART NUMBER
IDENTIFICATION DRAWING

START

NOTE: In the following steps, install the precision resistors with their value markings up, as shown below, so they can be easily read.



(•) 2 MΩ, precision resistor.

(•) 200 kΩ, precision resistor.

(•) 20 kΩ, precision resistor.

(•) 2000 Ω (2 k), precision resistor.

(•) 200 Ω, precision resistor.

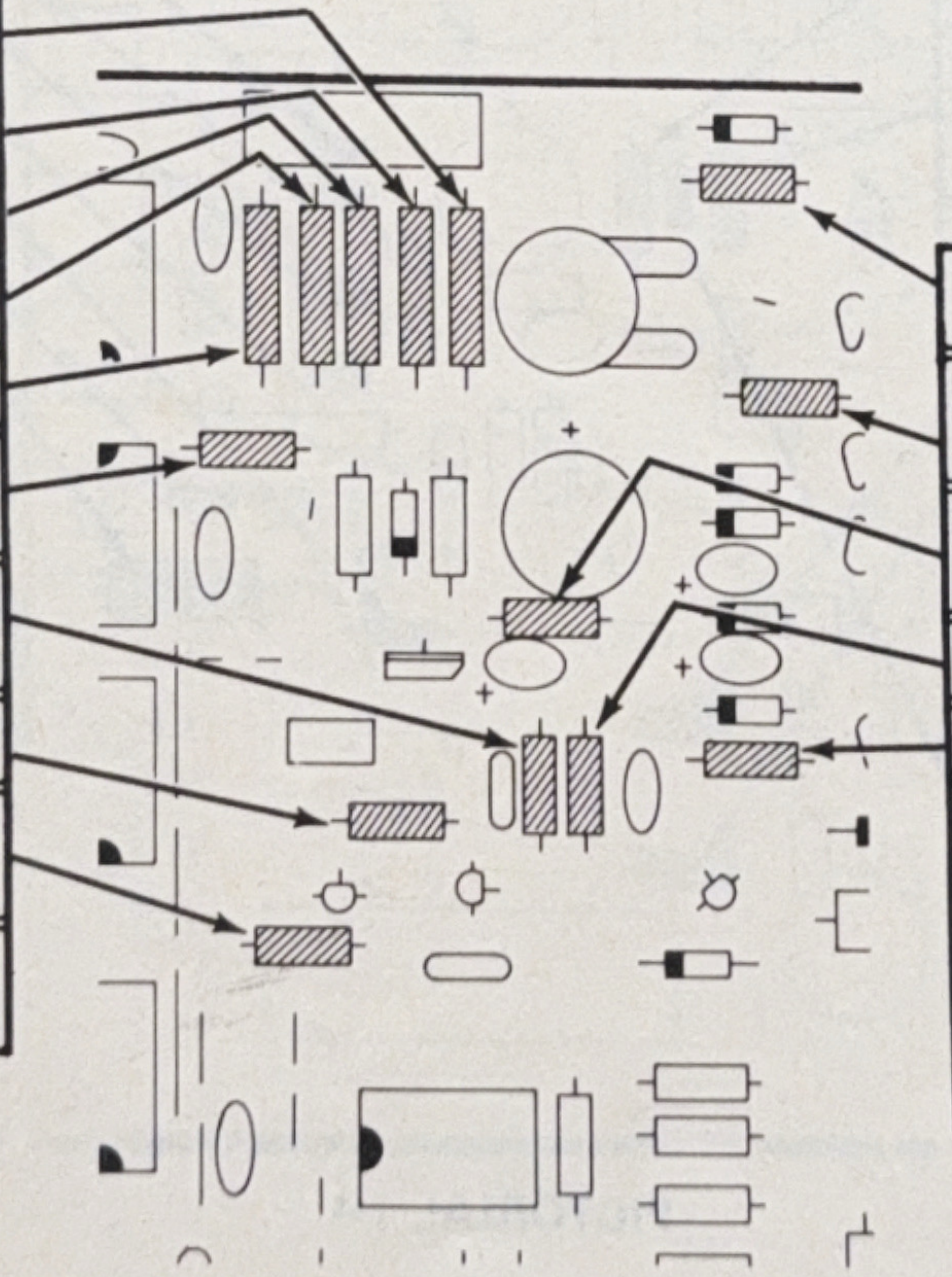
(•) 10 kΩ, 5% (brown-black-orange-gold).

(•) 3300 Ω, 5% (orange-orange-red-gold).

(•) 8200 Ω, 5% (gray-red-red-gold).

(•) 3300 Ω, 5% (orange-orange-red-gold).

(•) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

(•) 1 MΩ, 5% (brown-black-green-gold).

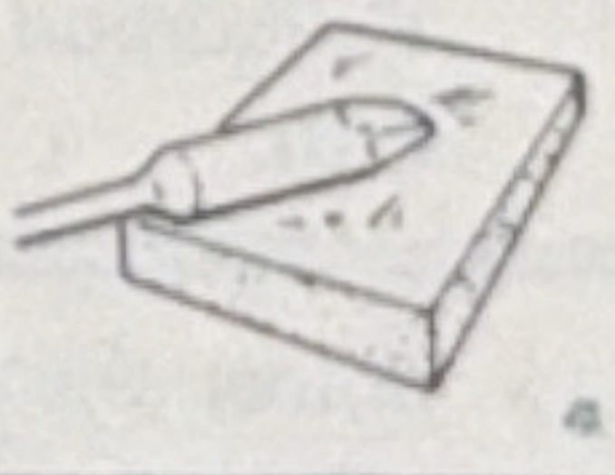
(•) 180 kΩ, 5% (brown-gray-yellow-gold).

(•) 3300 Ω, 5% (orange-orange-red-gold).

(•) 15 kΩ (brown-green-orange).

(•) 1000 Ω, 5% (brown-black-red-gold).

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN. WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.



(•) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-3

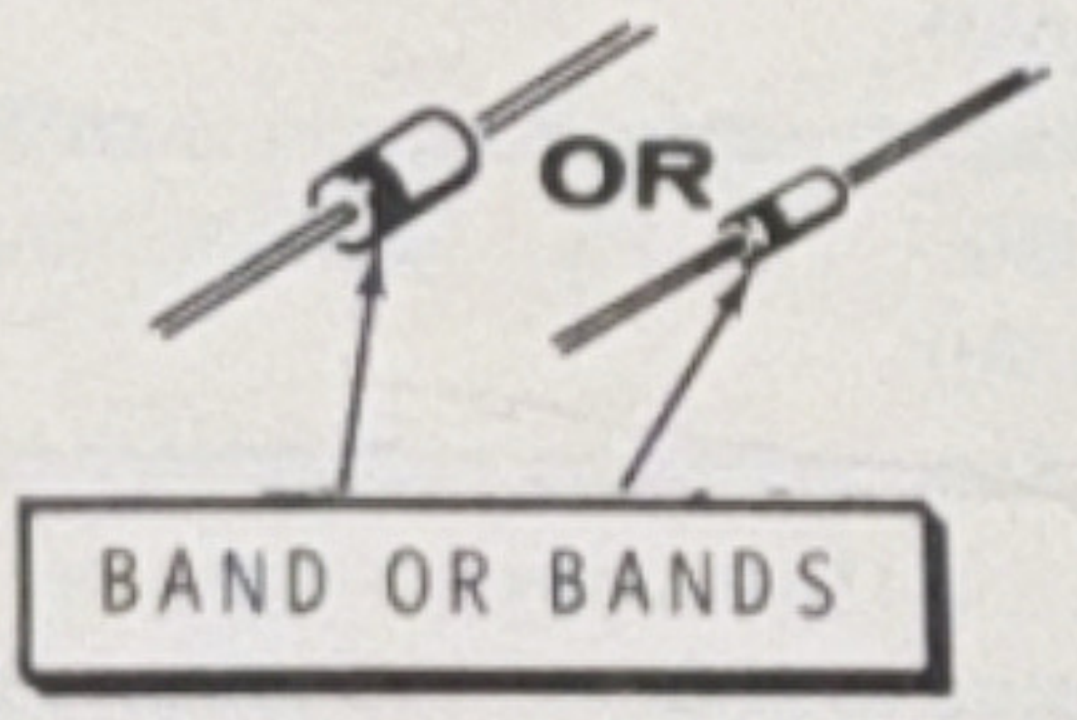
START

☑ Locate the envelope marked "100-1612 Calibration Voltage" and record the calibration voltage here. Calibration Voltage 1912
This information will be used later to calibrate your Multimeter.

☑ 22 kΩ, 5%, 1/4-watt (red-red-orange-gold) from Calibration Voltage envelope.

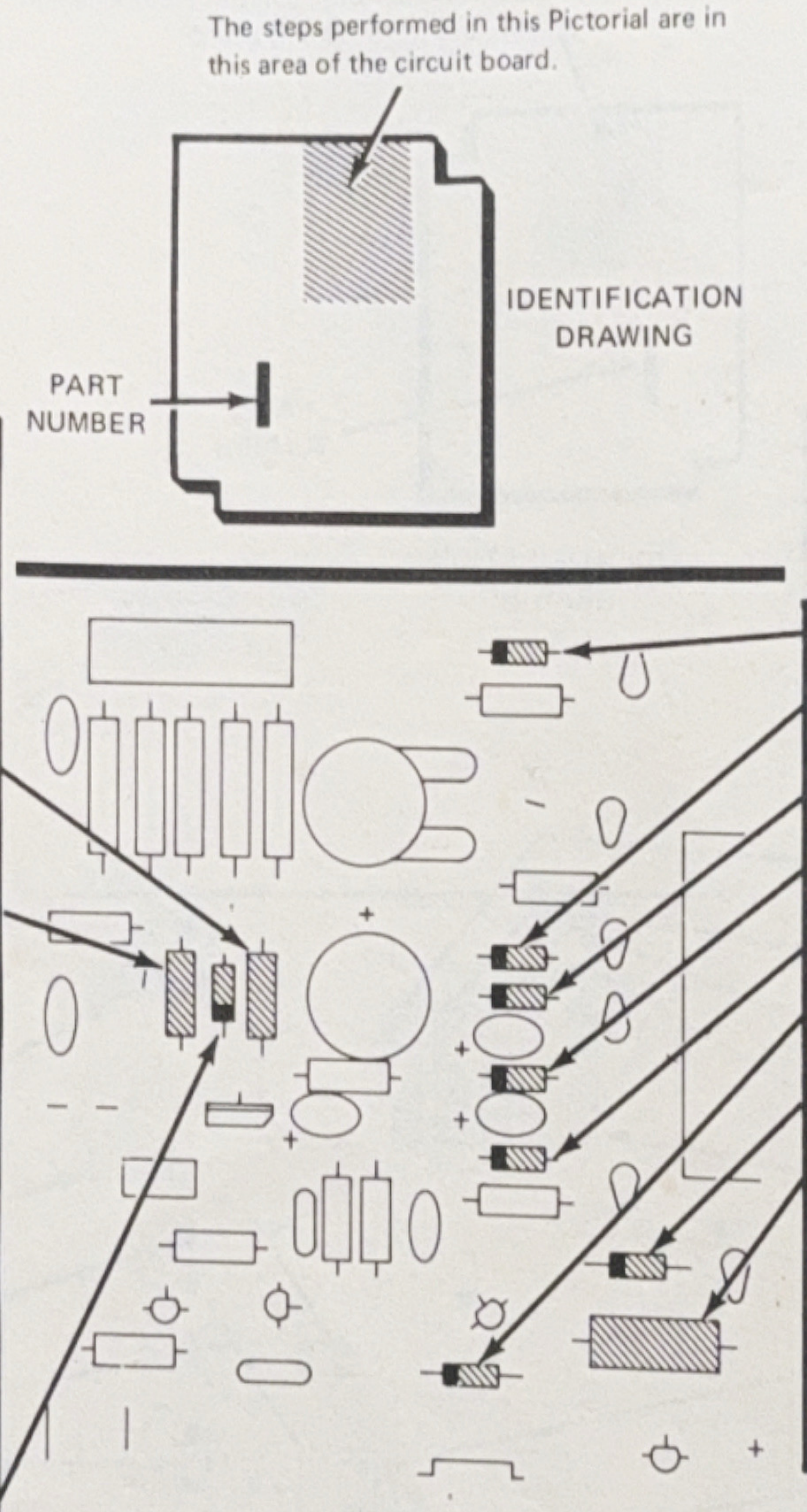
☑ 10 kΩ, 5%, 1/4-watt (brown-black-orange-gold) from Calibration Voltage envelope.

NOTE: THE FOLLOWING DIODE MAY BE SUPPLIED IN EITHER OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



☑ 1N709A diode #56-58 (from Calibration Voltage envelope) at D10.

☑ Solder the leads to the foil and cut off the excess lead lengths.


The steps performed in this Pictorial are in this area of the circuit board.
IDENTIFICATION DRAWING
PART NUMBER

CONTINUE

☑ 1N2071 diode (#57-27) at D16.

☑ 1N4002 diode (#57-65) at D11.

☑ 1N4002 diode (#57-65) at D12.

☑ 1N4166A diode (#56-25) at D15.

☑ 1N4166A diode (#56-25) at D14.

☑ 1N4149 diode (#56-56) at D17.

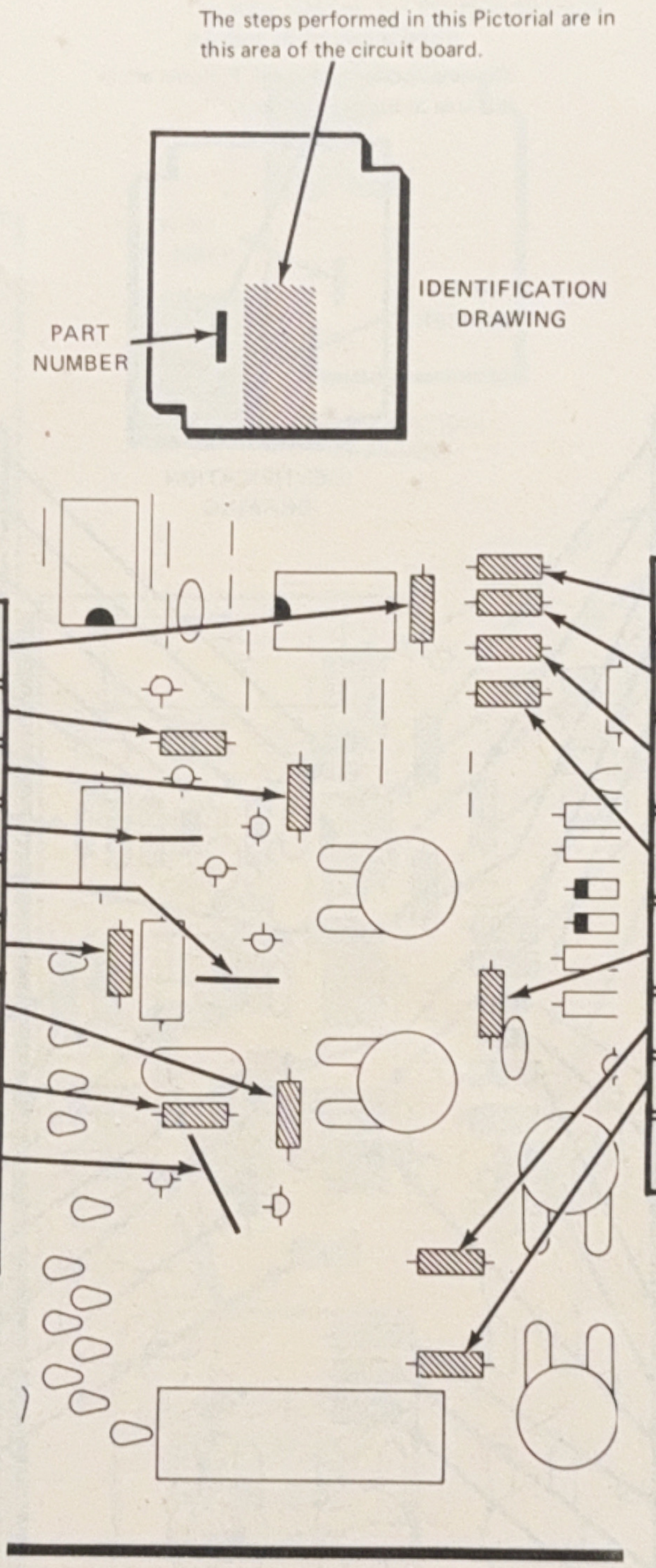
☑ 1N4002 diode (#57-65) at D13.

☑ 220 Ω, 1-watt (red-red-brown).

☑ Recheck each diode to make sure the banded end is positioned properly.

☑ Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-4


The steps performed in this Pictorial are in this area of the circuit board.
PART NUMBER
IDENTIFICATION DRAWING

START

( ) 390 Ω, 5% (orange-white-brown-gold).

( ) 2200 Ω, 5% (red-red-red-gold).

( ) 2200 Ω, 5% (red-red-red-gold).

( ) 1" jumper wire.

( ) 1-1/4" jumper wire.

( ) 1 MΩ, 5% (brown-black-green-gold).

( ) 1000 Ω, 5% (brown-black-red-gold).

( ) 100 Ω, 5% (brown-black-brown-gold).

( ) 1-1/4" jumper wire.

( ) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

( ) 390 Ω, 5% (orange-white-brown-gold).

( ) 390 Ω, 5% (orange-white-brown-gold).

( ) 390 Ω, 5% (orange-white-brown-gold).

( ) 390 Ω, 5% (orange-white-brown-gold).

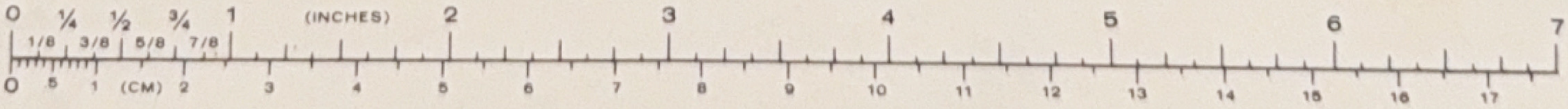
( ) 10 kΩ, 5% (brown-black-orange-gold).

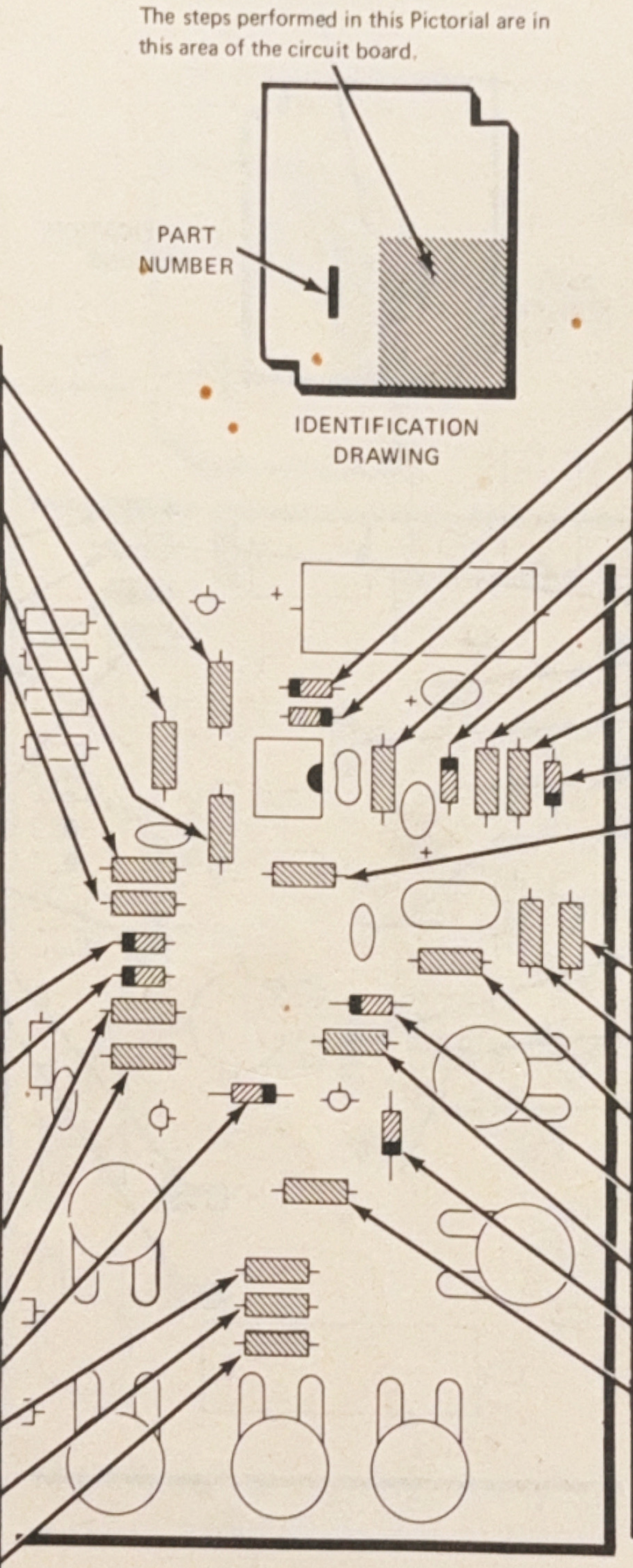
( ) 220 Ω, 5% (red-red-brown-gold).

( ) 4700 Ω, 5% (yellow-violet-red-gold).

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-5





The steps performed in this Pictorial are in this area of the circuit board.

START

(●) 15 kΩ (brown-green-orange).

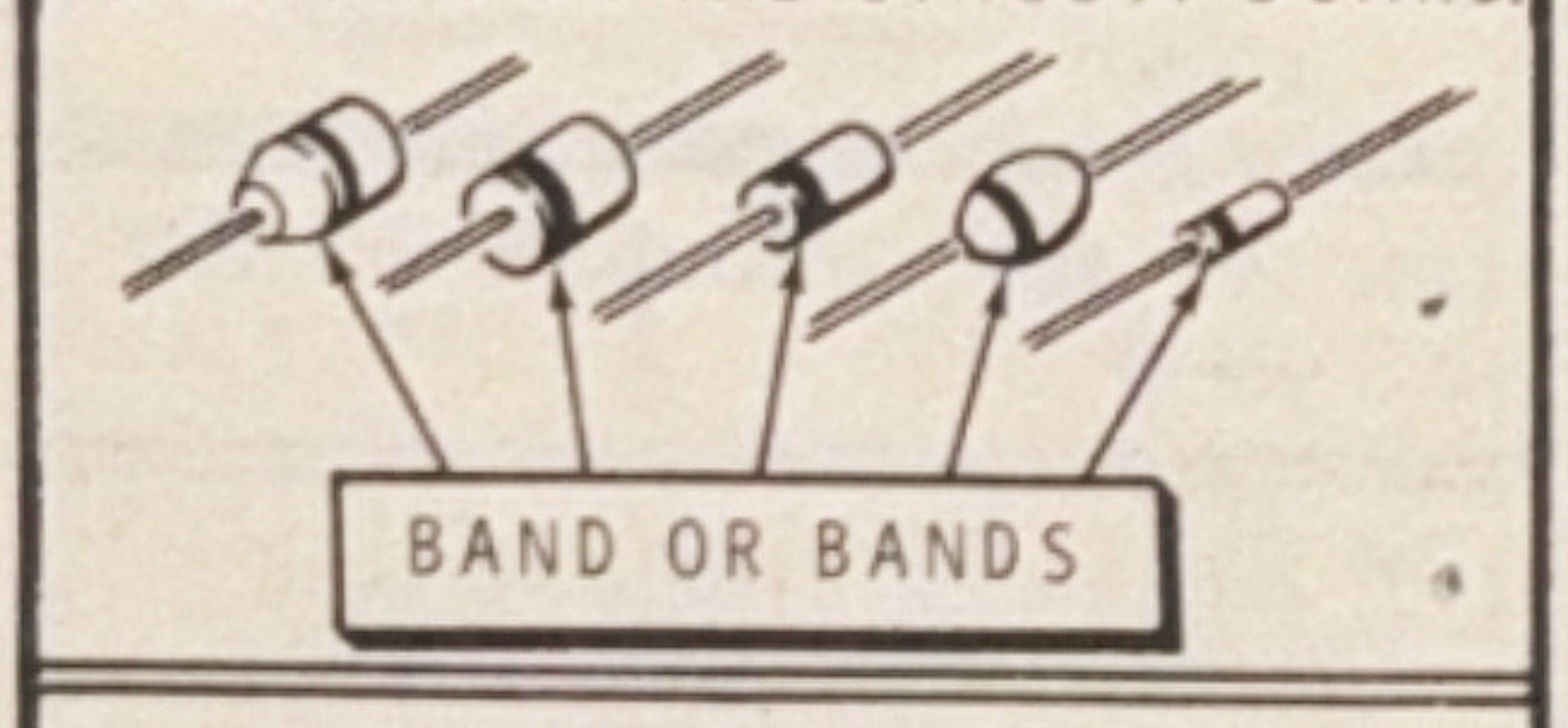
(●) 10 MΩ (brown-black-blue).

(●) 10 kΩ, 5% (brown-black-orange-gold).

(●) 1 MΩ, 5% (brown-black-green-gold).

(●) 5600 Ω (green-blue-red).

NOTE: DIODES MAY BE SUPPLIED IN ANY OF THE FOLLOWING SHAPES. ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



(●) 1N4149 diode (#56-56) at D5.

(●) 1N4149 diode (#56-56) at D4.

(●) Solder the leads to the foil and cut off the excess lead lengths.

(●) 330 kΩ, 5% (orange-orange-yellow-gold).

(●) 4700 Ω, 5% (yellow-violet-red-gold).

(●) 1N4149 diode (#56-56) at D3.

(●) 6.8 MΩ, 5% (blue-gray-green-gold).

(●) 680 kΩ (blue-gray-yellow).

(●) 47 kΩ, 5% (yellow-violet-orange-gold).

(●) Solder the leads to the foil and cut off the excess lead lengths.

CONTINUE

(●) 1N4149 diode (#56-56) at D7.

(●) 1N4149 diode (#56-56) at D6.

(●) 1 MΩ, 5% (brown-black-green-gold).

(●) 1N4149 diode (#56-56) at D8.

(●) 12 kΩ, 5% (brown-red-orange-gold).

(●) 12 kΩ, 5% (brown-red-orange-gold).

(●) 1N4149 diode (#56-56) at D9.

(●) 1000 Ω, 5% (brown-black-red-gold).

(●) Solder the leads to the foil and cut off the excess lead lengths.

(●) 4700 Ω, 5% (yellow-violet-red-gold).

(●) 100 kΩ, 5% (brown-black-yellow-gold).

(●) 330 kΩ, 5% (orange-orange-yellow-gold).

(●) 1N2071 diode (#57-27) at D1.

(●) 8200 Ω, 5% (gray-red-red-gold).

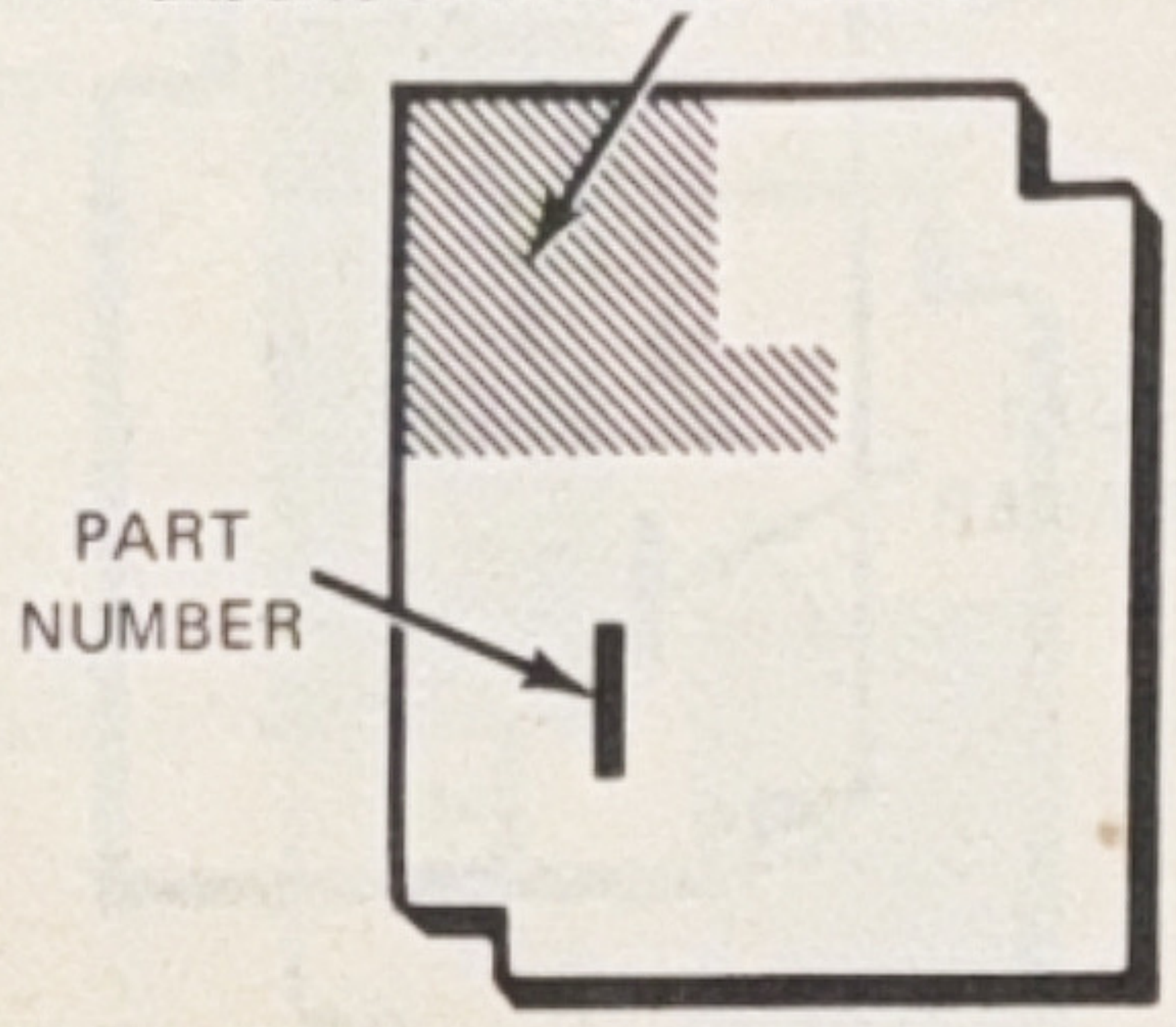
(●) 1N2071 diode (#57-27) at D2.

(●) 100 Ω, 5% (brown-black-brown-gold).

(●) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-6

The steps performed in this Pictorial are in this area of the circuit board.

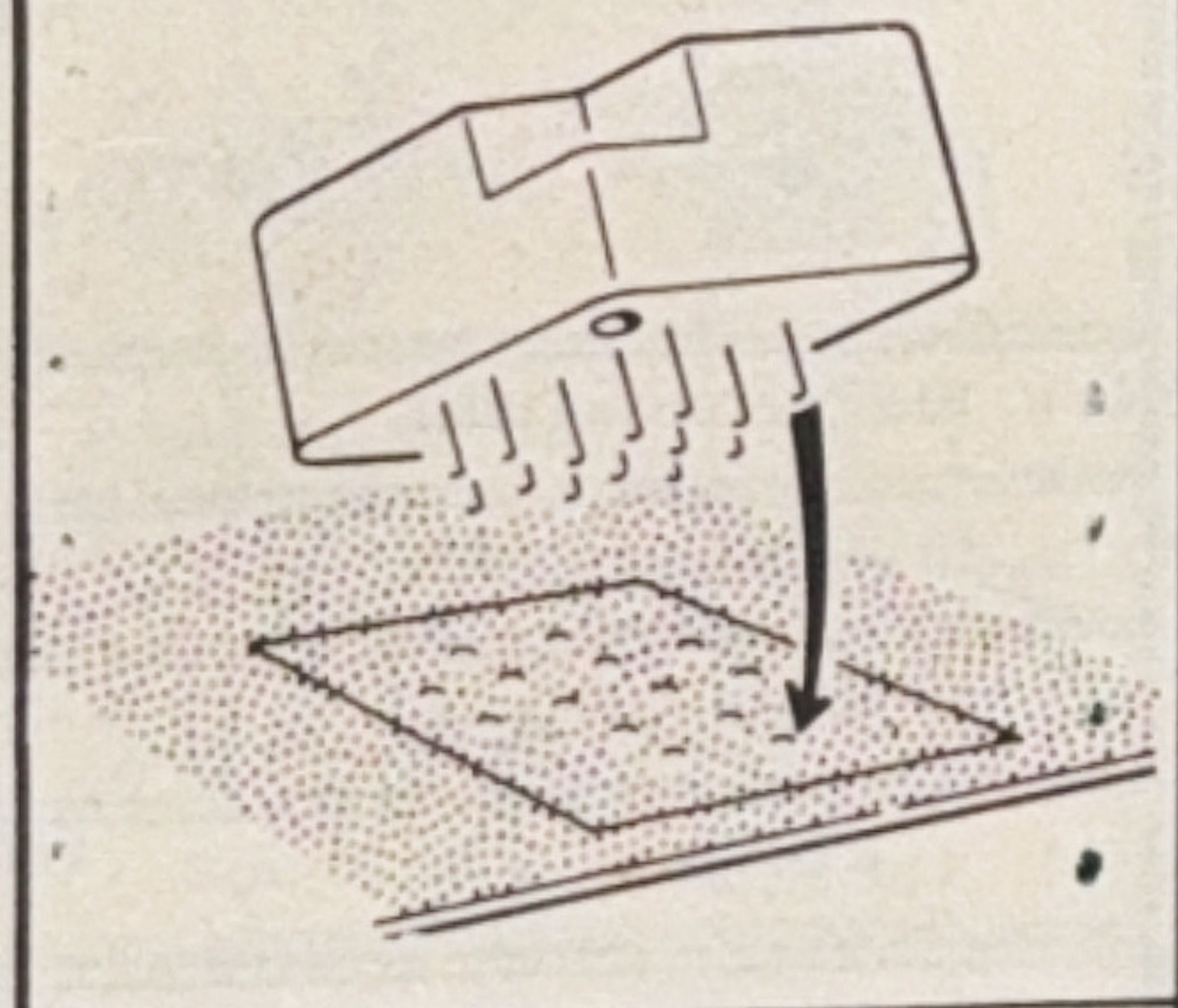


IDENTIFICATION DRAWING

START

NOTE: Read this information carefully before you install the sockets in the following steps. First, be sure to position the socket as shown. Then solder the pins of each socket when you install it.

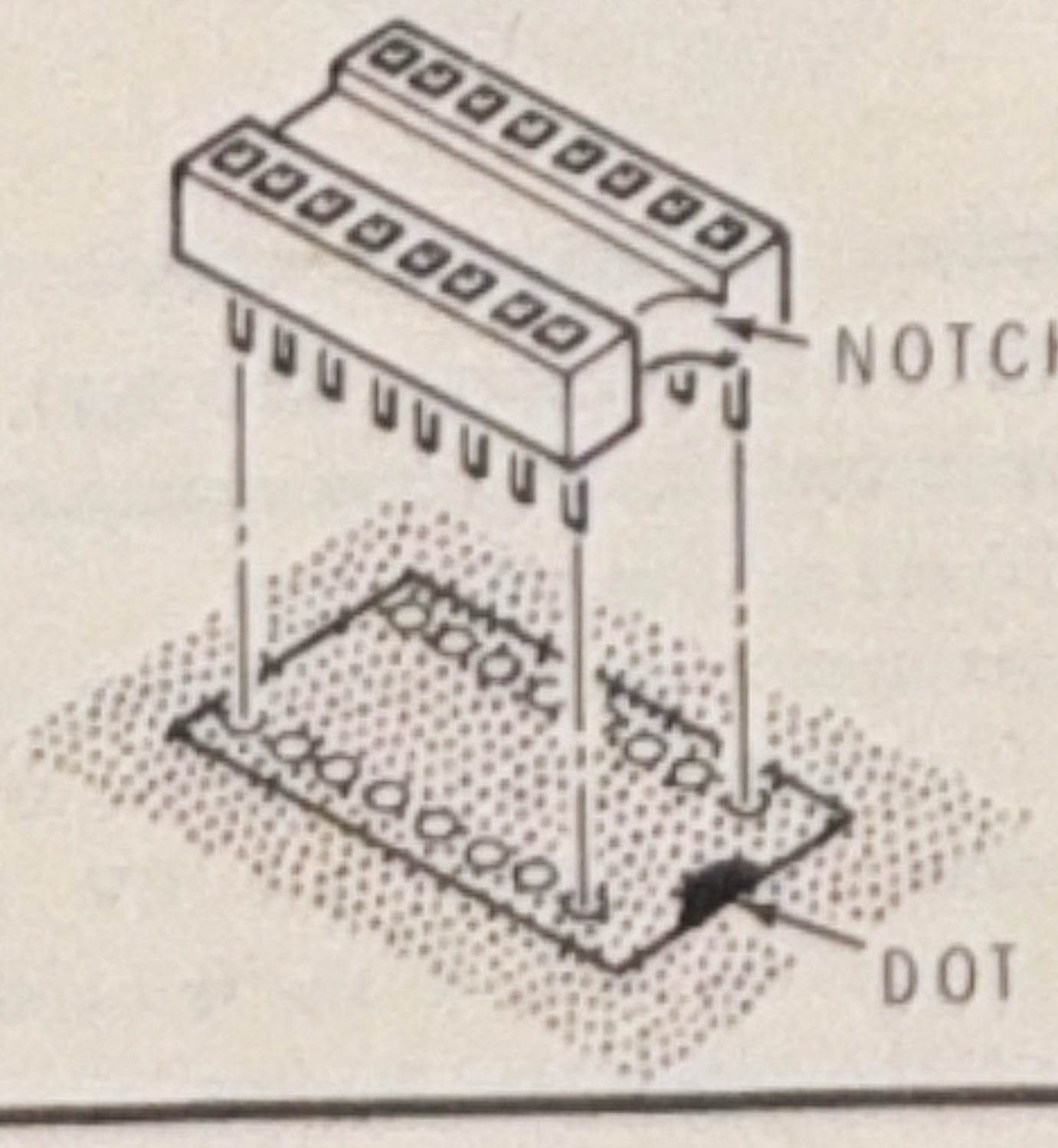
CAUTION: The tube socket and IC socket pins are very close together. Therefore, be sure you do not bridge solder between pins on different foils. When you remove the soldering iron, move the tip of the iron straight up from the pin to avoid bridging solder to another pin. Do not place the soldering iron tip between the socket pins when soldering, as this increases the possibility of a solder bridge.

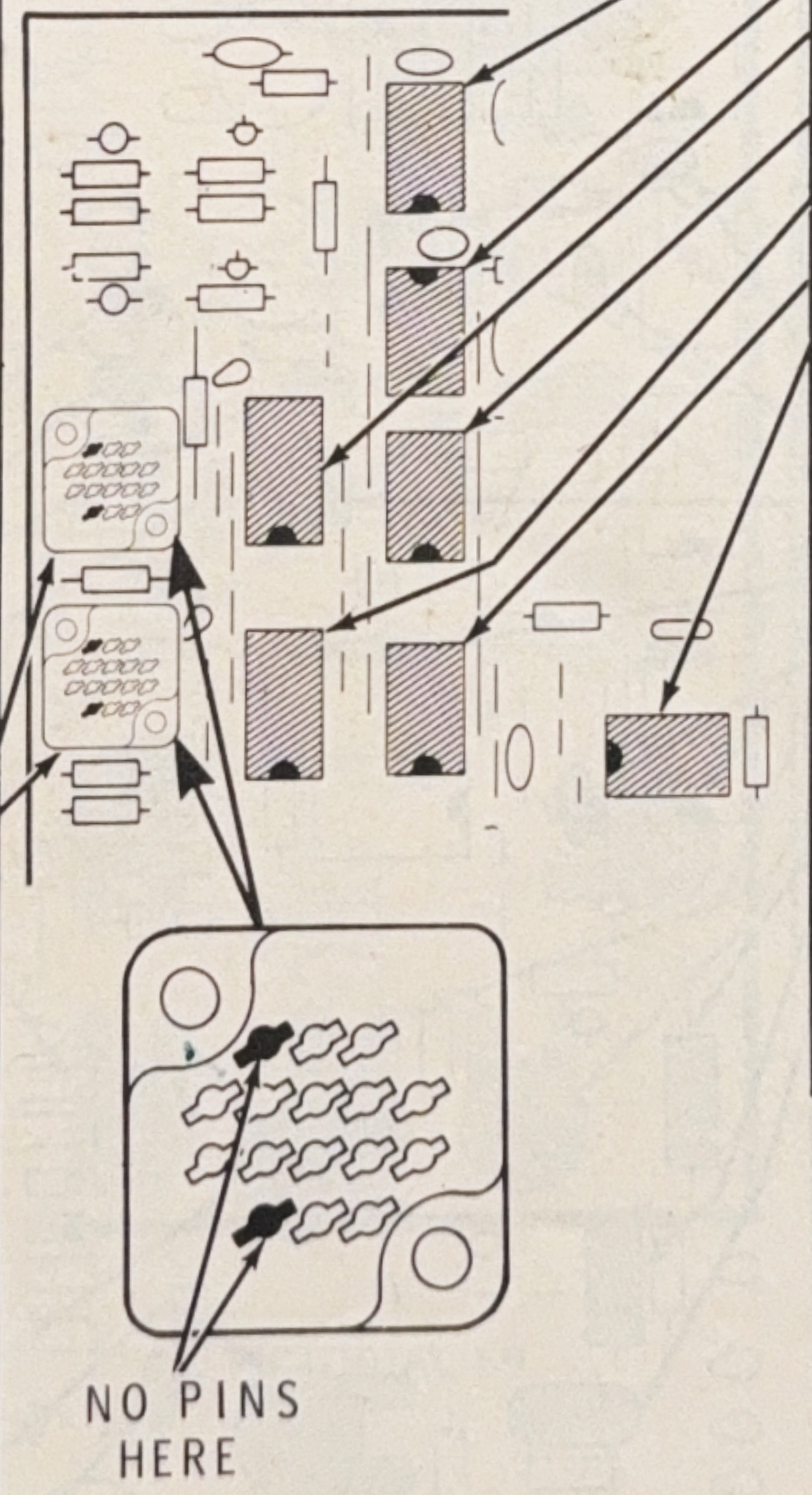


(•) Tube socket at V2.

(•) Tube socket at V1.

NOTE: Both 14-pin and 16-pin dual-in-line IC's and sockets are used in this kit. Be very careful when you install the sockets, as it is possible to place a 14-pin socket in a 16-pin socket location by mistake. Make sure the notched end of the socket is lined up with the dot on the circuit board and that all pins are in their holes before soldering.





PICTORIAL 1-7

CONTINUE

Solder each IC socket to the foil as you install it.

(•) 14-pin IC socket at IC5.

(•) 14-pin IC socket at IC8. Note the position of the notched end.

(•) 16-pin IC socket at IC3.

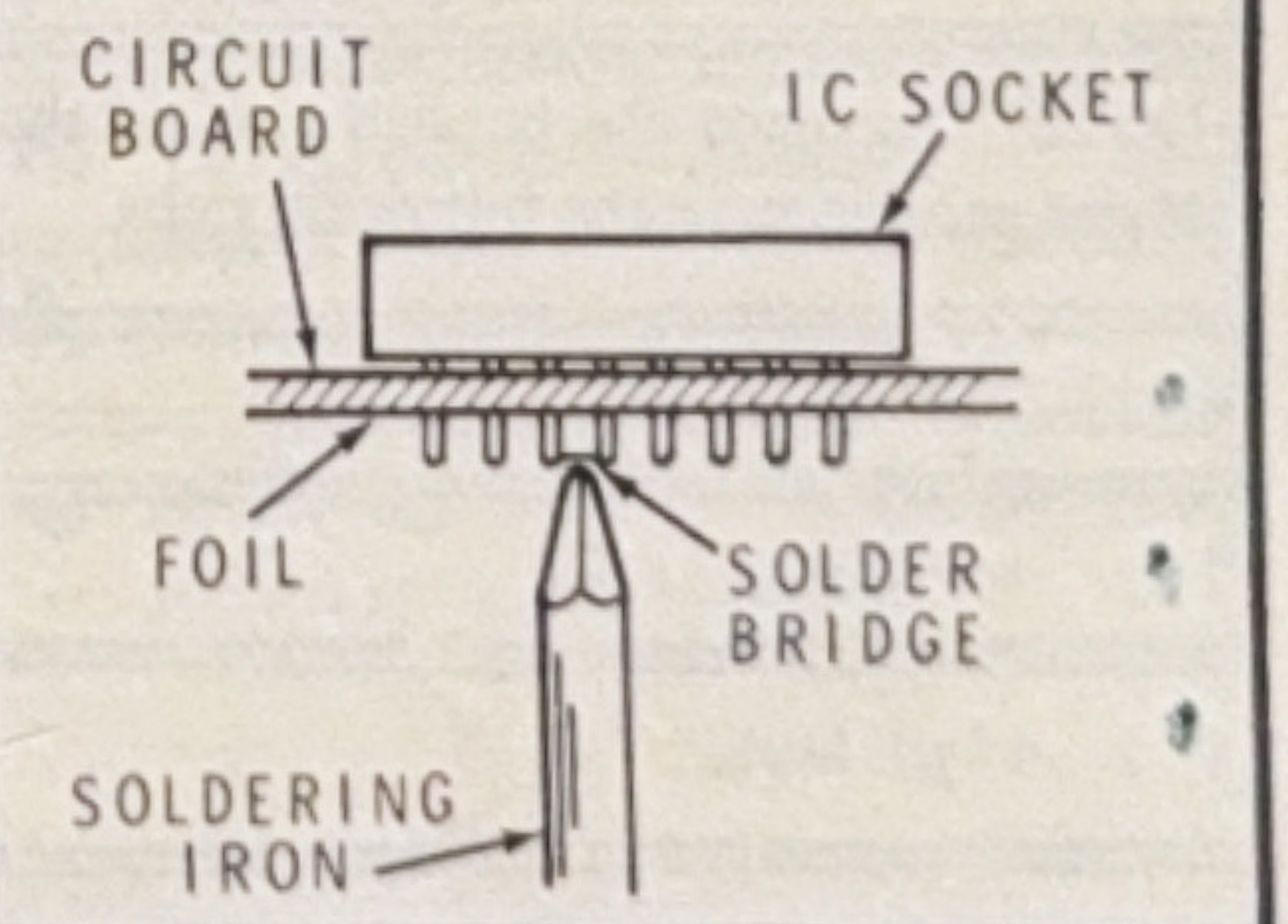
(•) 14-pin IC socket at IC6.

(•) 16-pin IC socket at IC4.

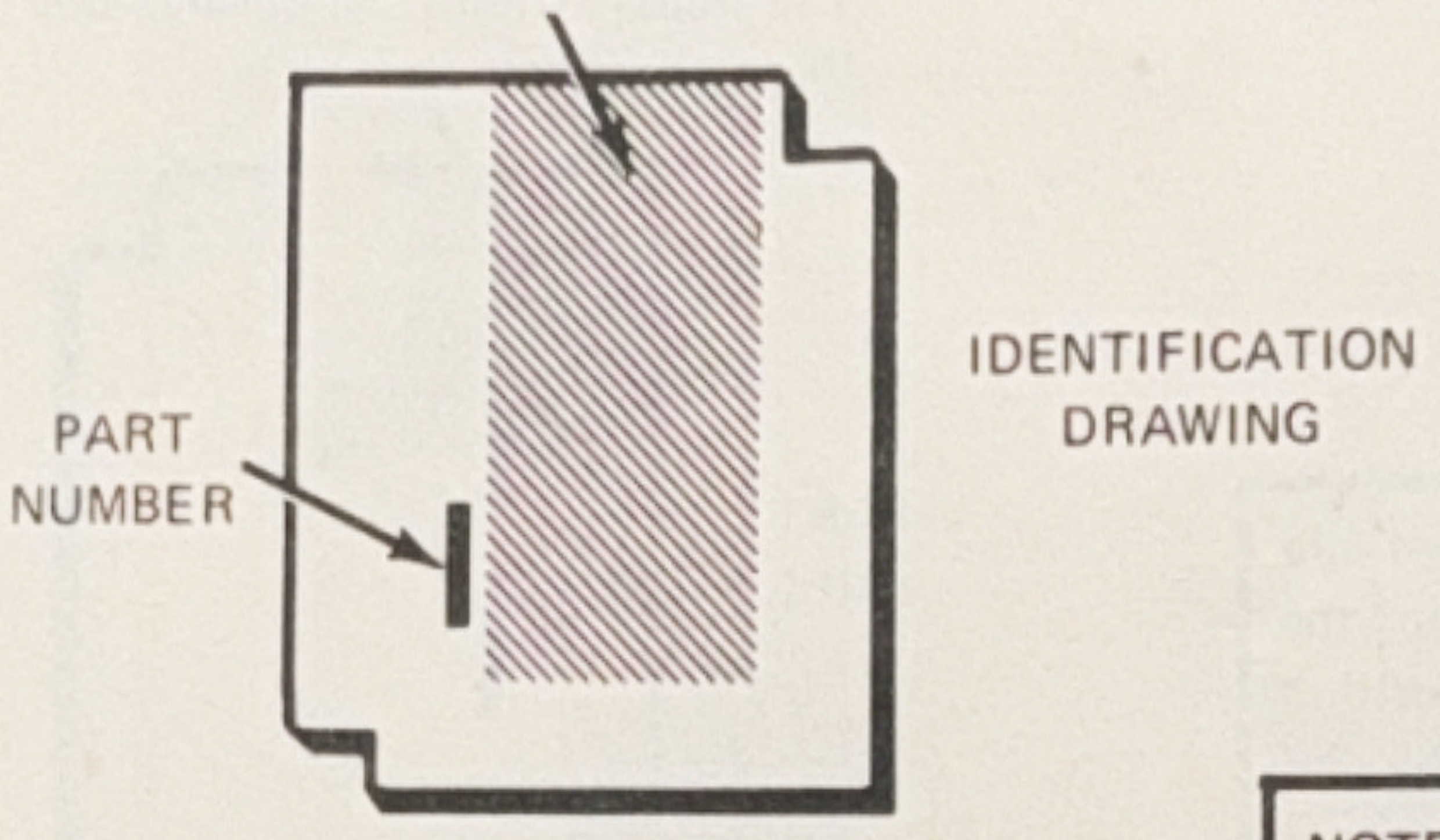
(•) 14-pin IC socket at IC7.

(•) 14-pin IC socket at IC2.

Carefully check each socket for solder bridges between pins. If a solder bridge has occurred, hold the circuit board foil-side-down as shown, and hold the soldering iron tip between the two points that are bridged. The solder will flow down the soldering iron tip.



The steps performed in this Pictorial are in this area of the circuit board.

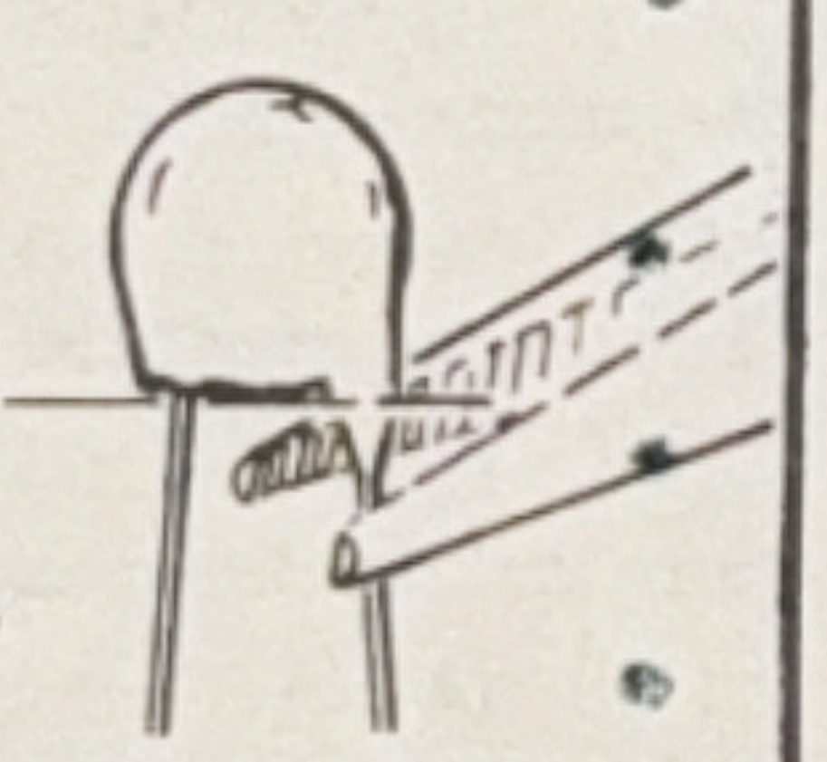


START

(✓) .1 µF Mylar.

(✓) .1 µF Mylar.

NOTE: Check the leads of each disc, mica or Mylar capacitor as you install it. Remove the coating from each capacitor as shown. This coating could cause a bad solder connection.



(✓) .001 µF disc.

(✓) .05 µF disc.

(✓) .0022 µF Mylar.

(✓) .0022 µF Mylar.

(✓) .1 µF Mylar.

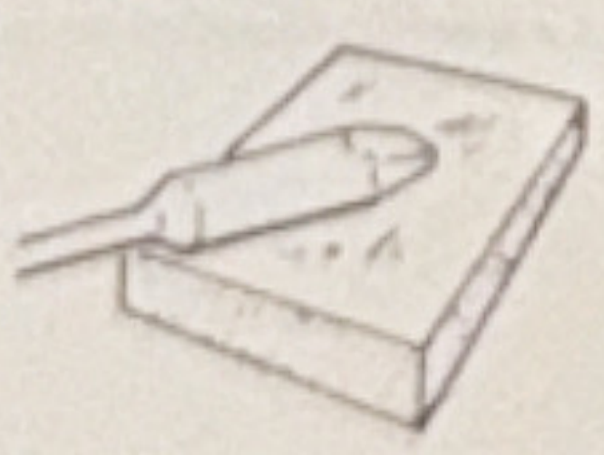
NOTE: Disregard the banded end on the Mylar capacitors in the following steps.

(✓) .1 µF Mylar.

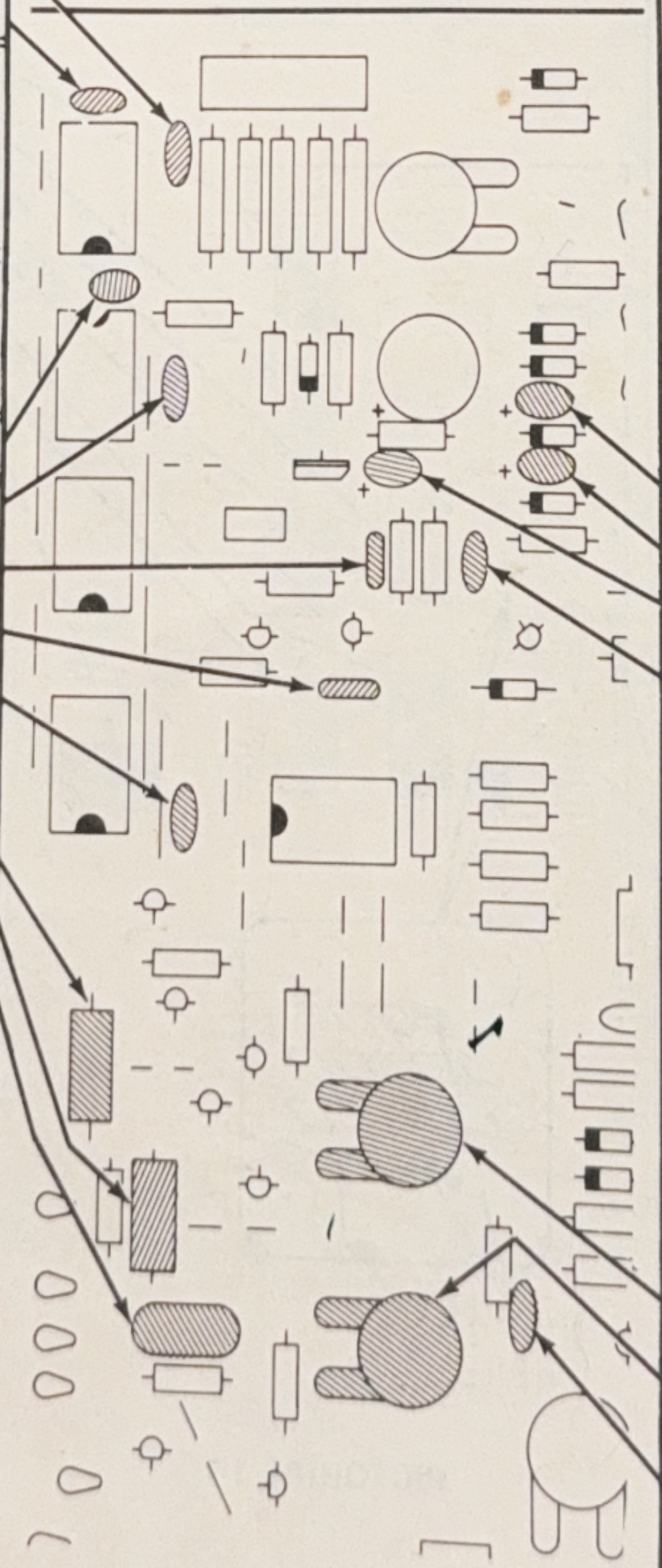
(✓) .1µF Mylar.

(✓) .47 µF Mylar.

FOR GOOD SOLDERED CONNECTIONS, YOU MUST KEEP THE SOLDERING IRON TIP CLEAN. WIPE IT OFTEN WITH A DAMP SPONGE OR CLOTH.

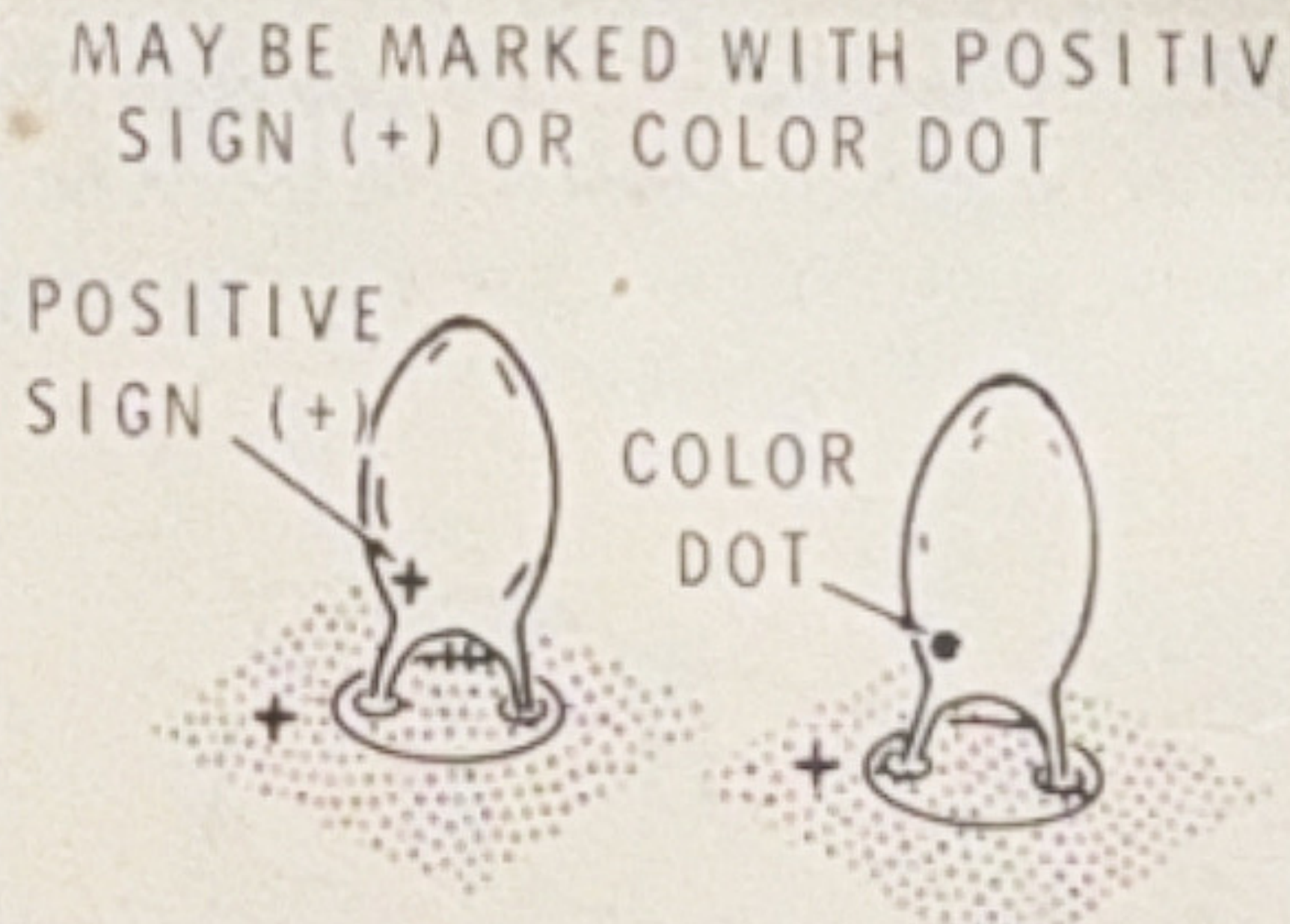


(✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

NOTE: Tantalum capacitors may be marked either of two ways, as shown. When you install the following capacitor, be sure to match the positive (+) sign or color dot with the positive (+) marking on the circuit board.



(✓) 10 µF tantalum (10M).

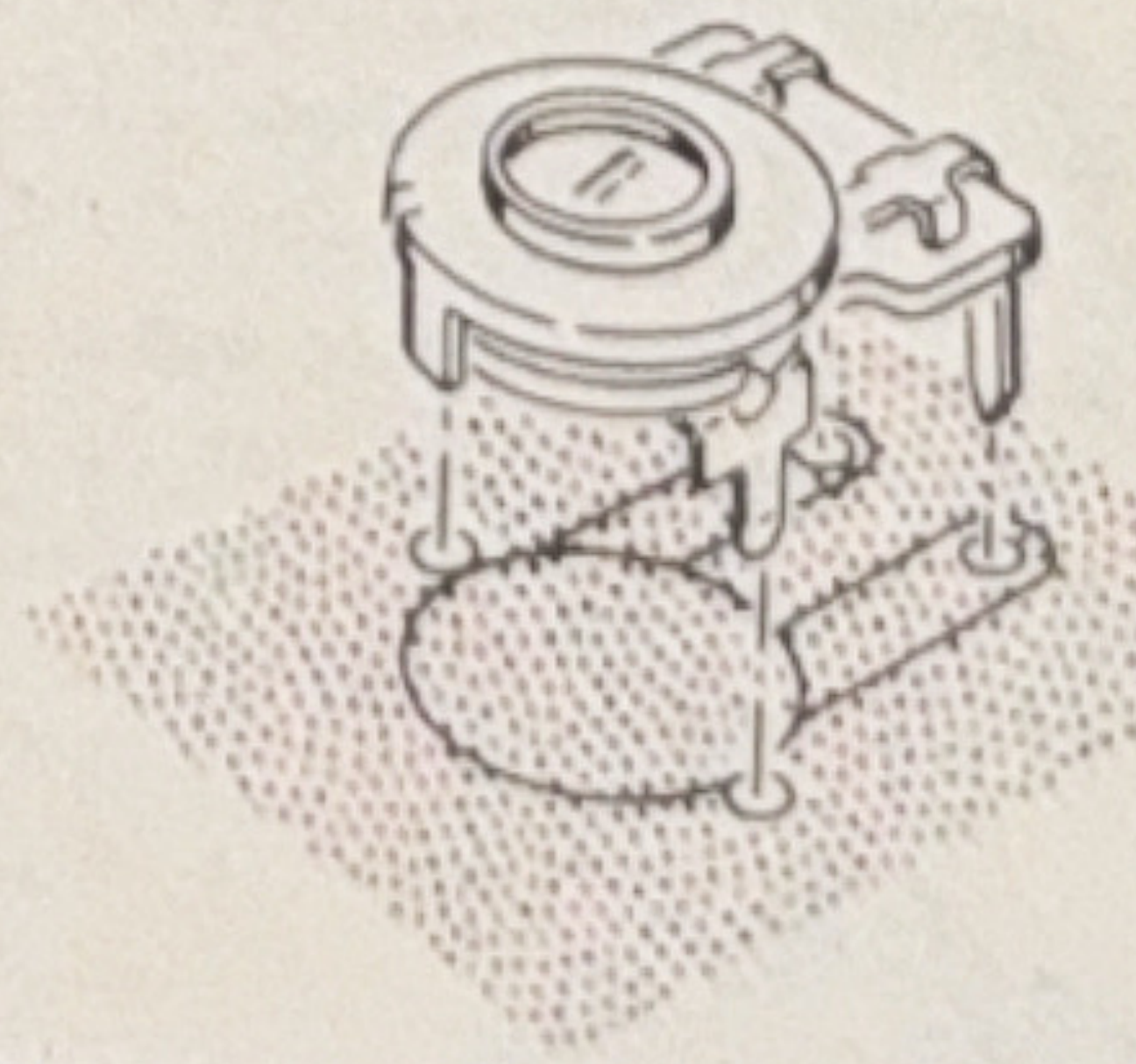
(✓) 10 µF tantalum (10M).

(✓) 47 µF tantalum (47M).

(✓) .1 µF Mylar.

(✓) Solder the leads to the foil and cut off the excess lead lengths.

NOTE: When you install controls in the following steps, push each control down onto the surface of the circuit board. Then solder all the lugs to the foil.



(✓) 2000 Ω (2 k) control (#10-382).

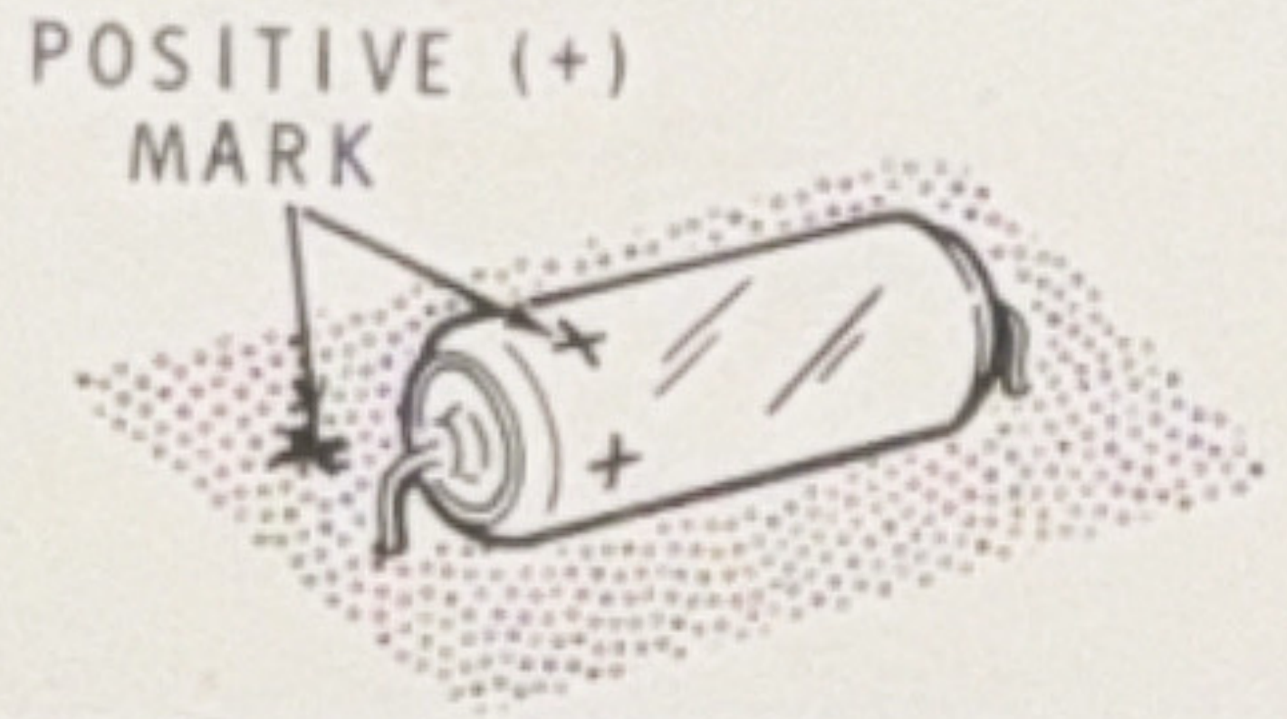
(✓) 20 kΩ control (#10-388).

(✓) .01 µF disc. Do not use the .01 µF capacitor marked 1.4 kV here. Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-8

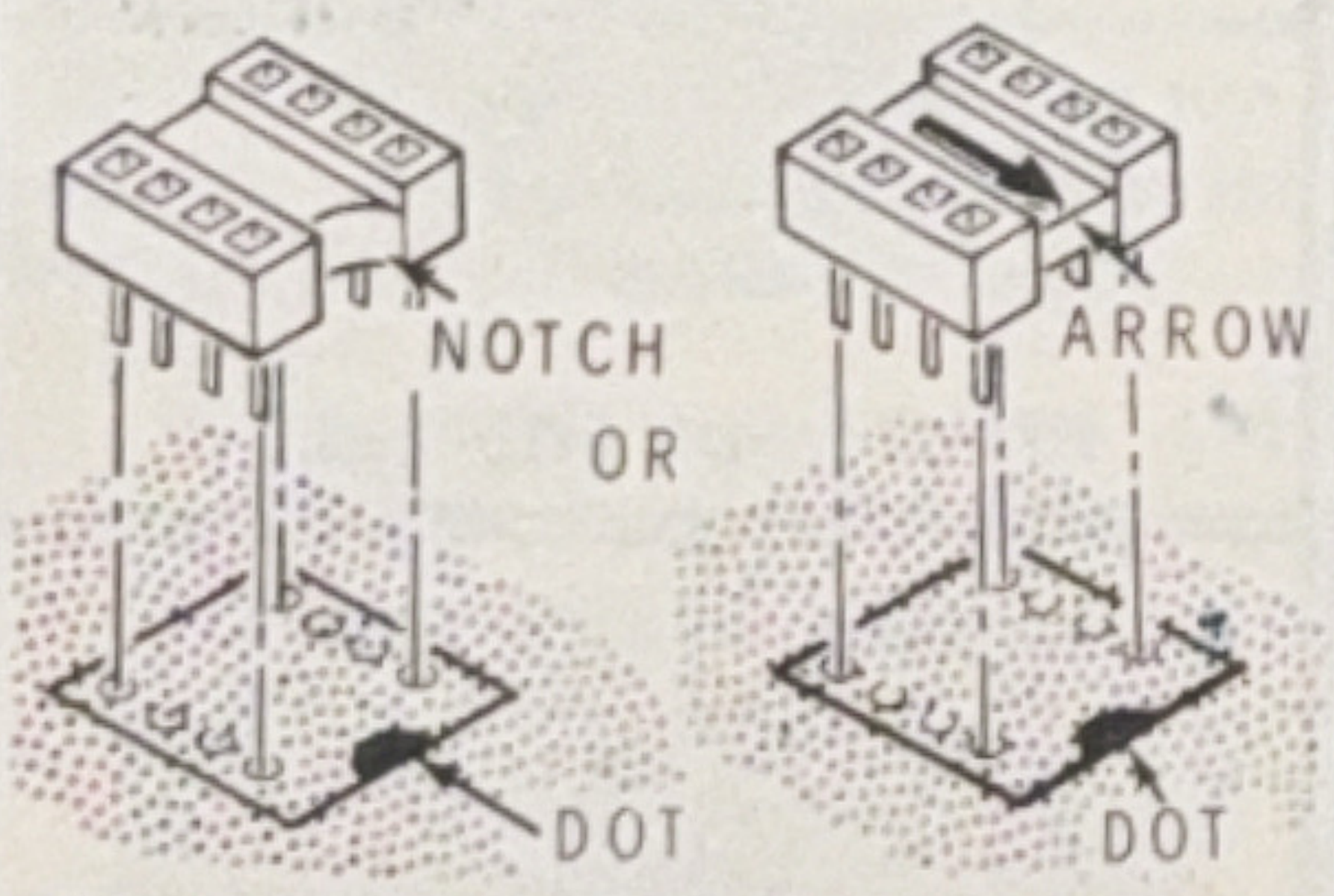
START

NOTE: When you install electrolytic capacitors, always match the positive (+) markings on the capacitor with the positive (+) mark on the circuit board.



☑ 100 µF electrolytic.

NOTE: The 8-pin IC socket used in this step may be marked with either a notched end or an arrow. When you install the socket, line up the notched end or the arrowhead with the dot on the circuit board. Then solder the pins to the foil.



☑ 8-pin IC socket at IC1.

☑ .1 µF Mylar.

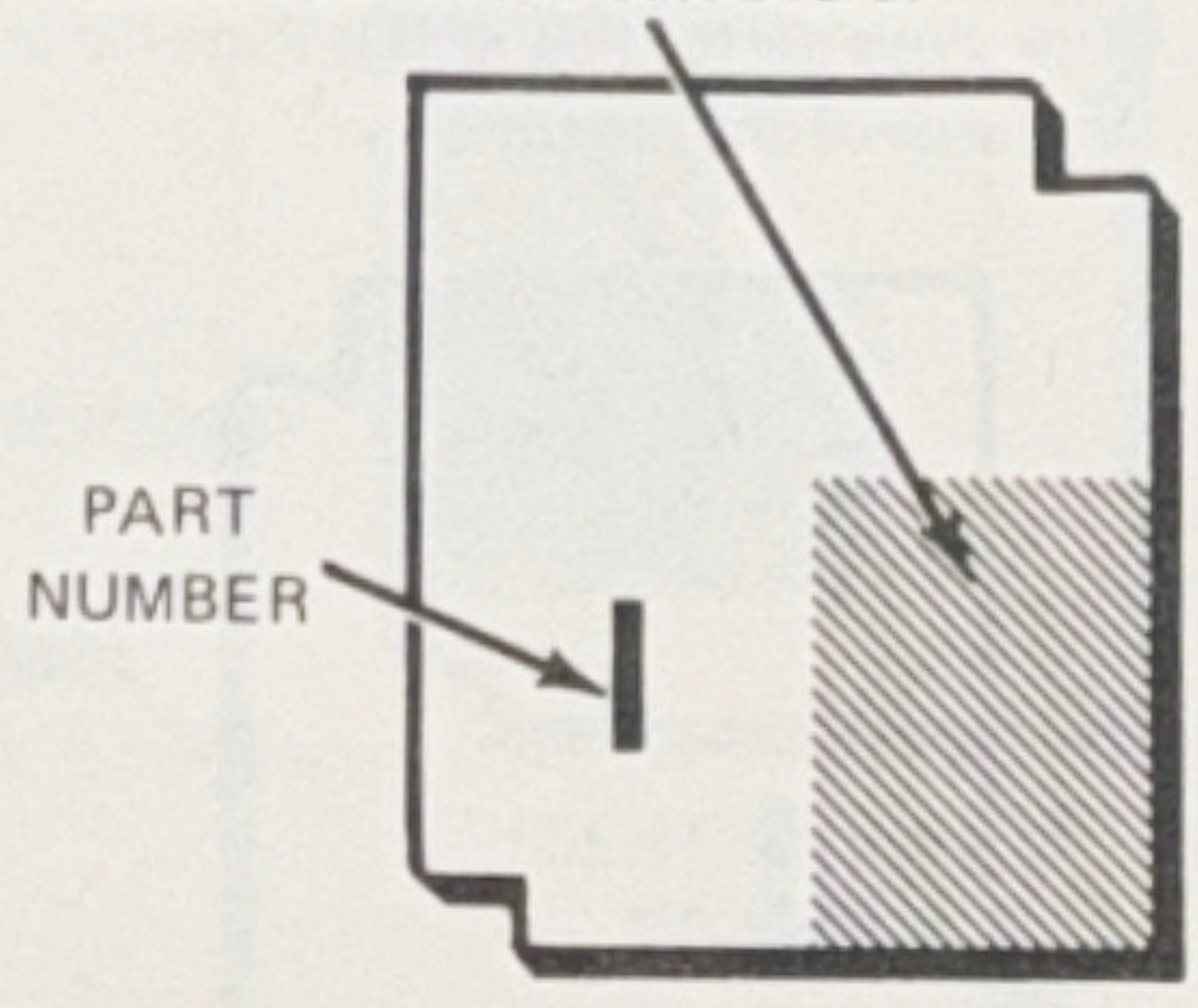
☑ .1 µF Mylar.

☑ 2000 Ω (2 k) control (#10-382).

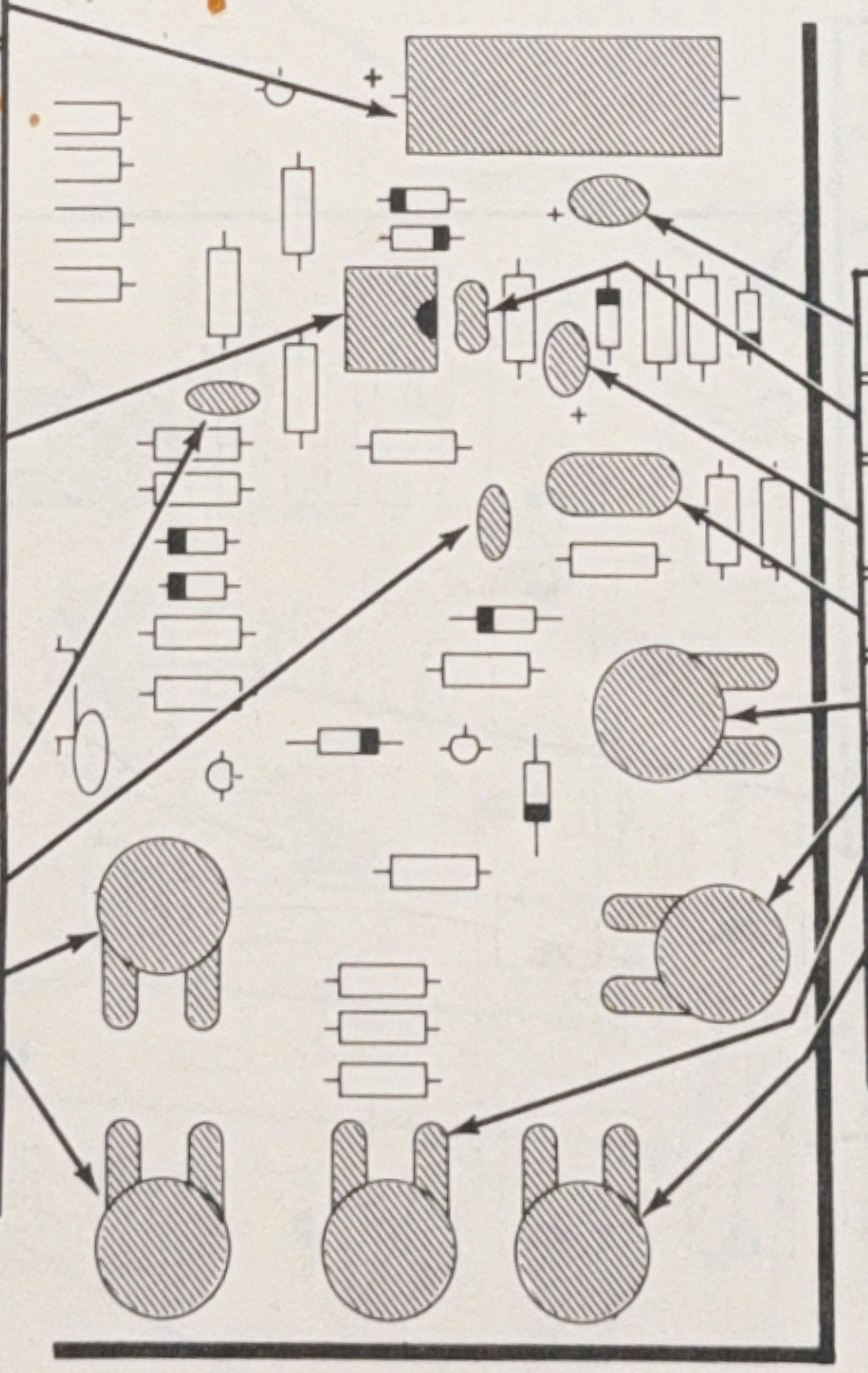
☑ 10 kΩ control (#10-383).

☑ Solder the leads to the foil and cut off the excess lead lengths.

The steps performed in this Pictorial are in this area of the circuit board.



IDENTIFICATION DRAWING



CONTINUE

☑ 10 µF tantalum (10M). Make sure the (+) mark is positioned correctly.

☑ 7.5 pF mica.

☐ 47 µF tantalum (47M). Make sure the (+) mark is positioned correctly.

☑ .47 µF Mylar.

☑ 2000 Ω (2 k) control (#10-382).

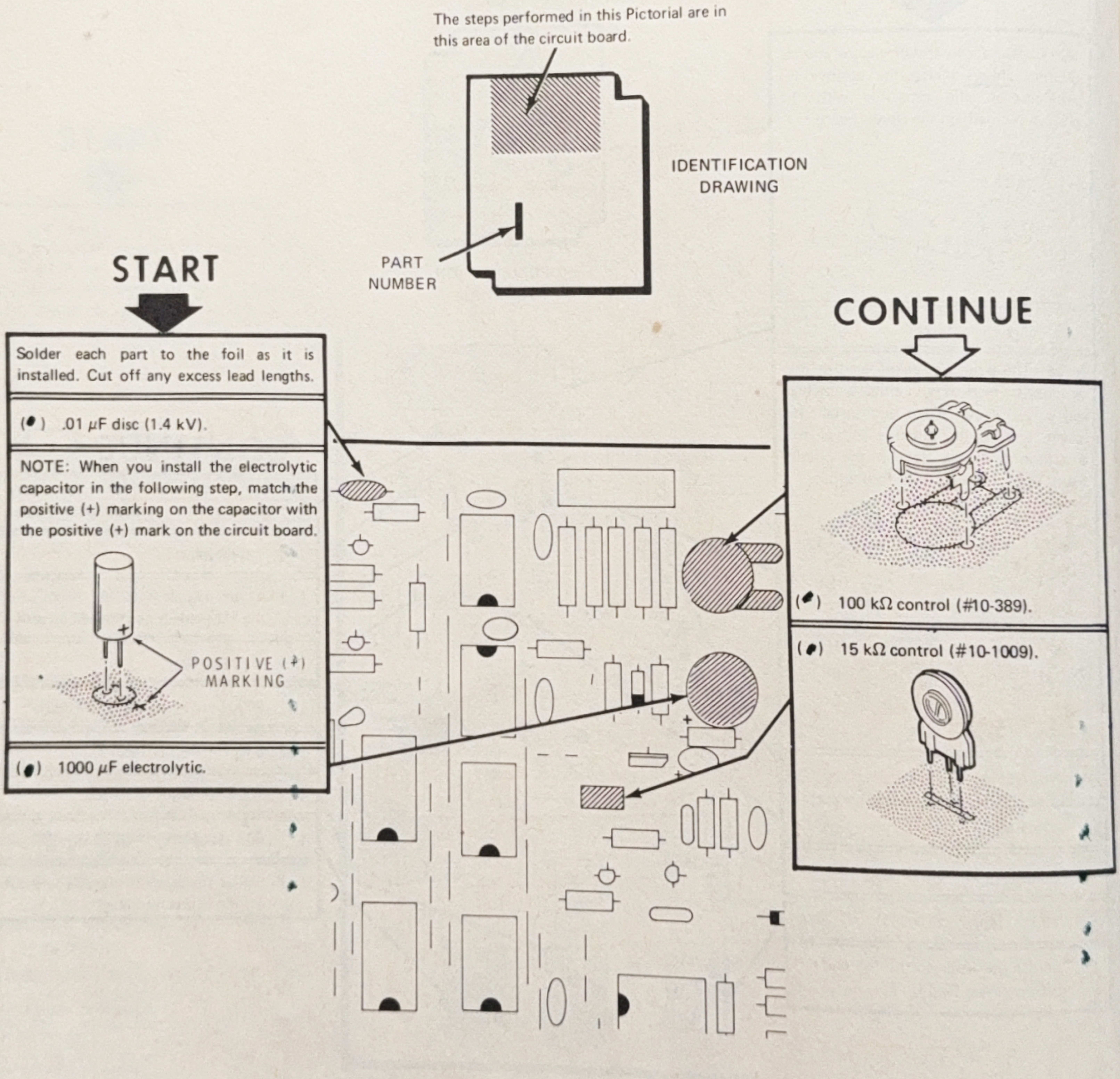
☑ 5 MΩ control (#10-393).

☑ 100 kΩ control (#10-389).

☑ 500 kΩ control (#10-384).

☑ Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-9



The steps performed in this Pictorial are in this area of the circuit board.

Solder each part to the foil as it is installed. Cut off any excess lead lengths.

(✓) .01 μF disc (1.4 kV).

NOTE: When you install the electrolytic capacitor in the following step, match the positive (+) marking on the capacitor with the positive (+) mark on the circuit board.

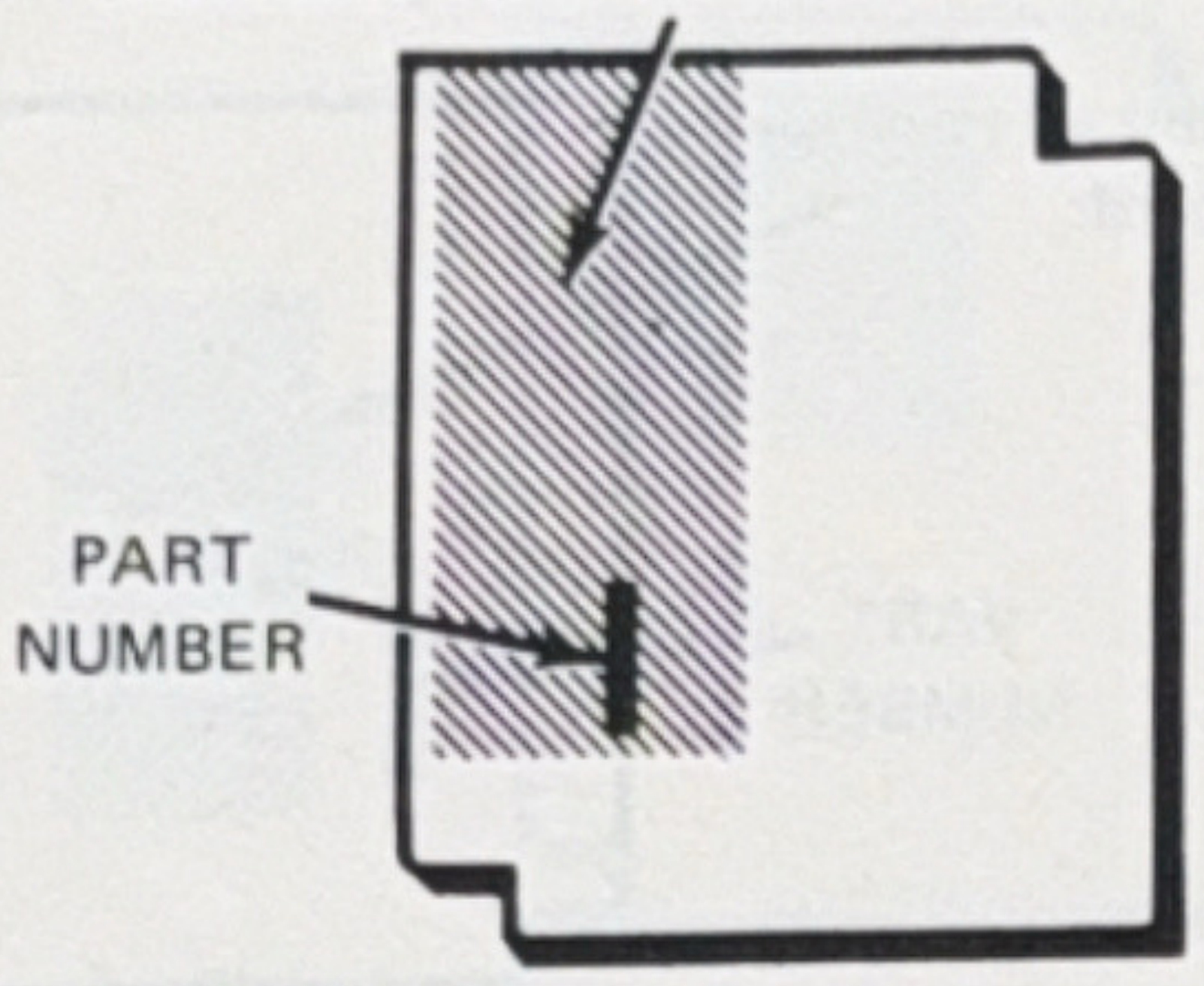
(✓) 1000 μF electrolytic.

(✓) 100 kΩ control (#10-389).

(✓) 15 kΩ control (#10-1009).

PICTORIAL 1-10

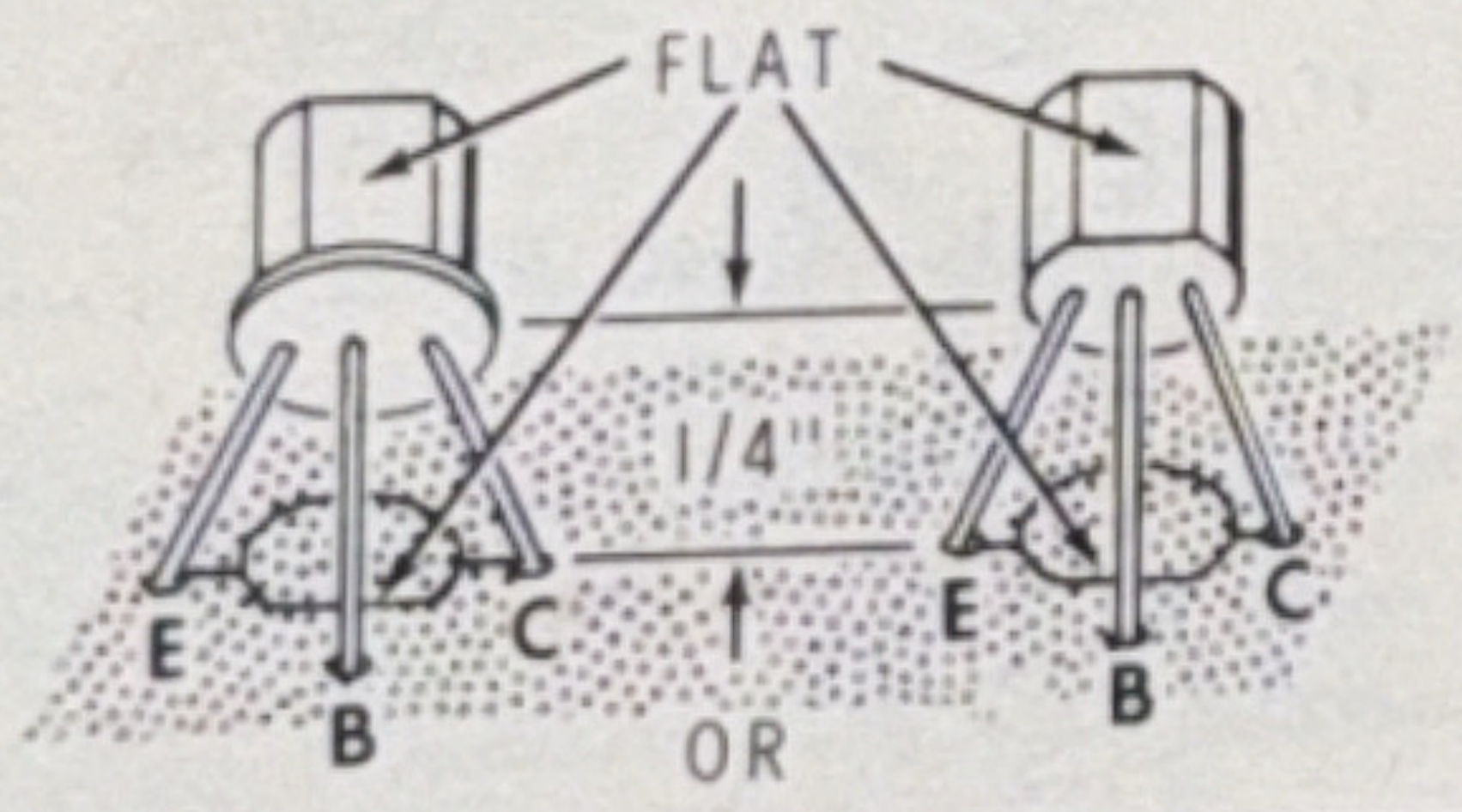
The steps performed in this Pictorial are in this area of the circuit board.



IDENTIFICATION DRAWING

START

NOTE: Install each of the following transistors as shown. Solder each lead to the foil and cut off the excess lead lengths.

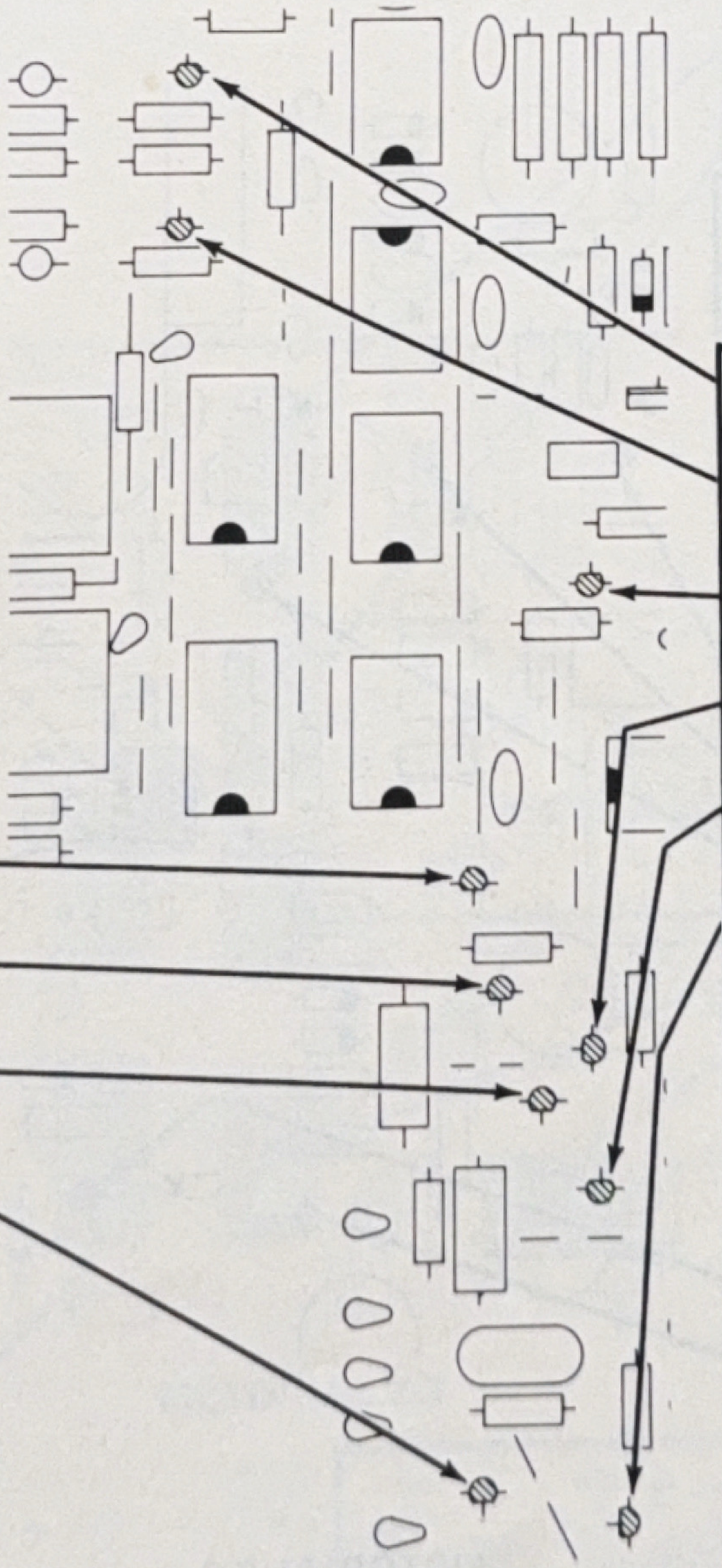


(✓) 2N3638A transistor (#417-234) at Q6.

(✓) MPSA20 transistor (#417-801) at Q2.

(✓) MPS6520 transistor (#417-134) at Q1.

(✓) MPSA20 transistor (#417-801) at Q5.



CONTINUE

(✓) MPSA42 transistor (#417-294) at Q13.

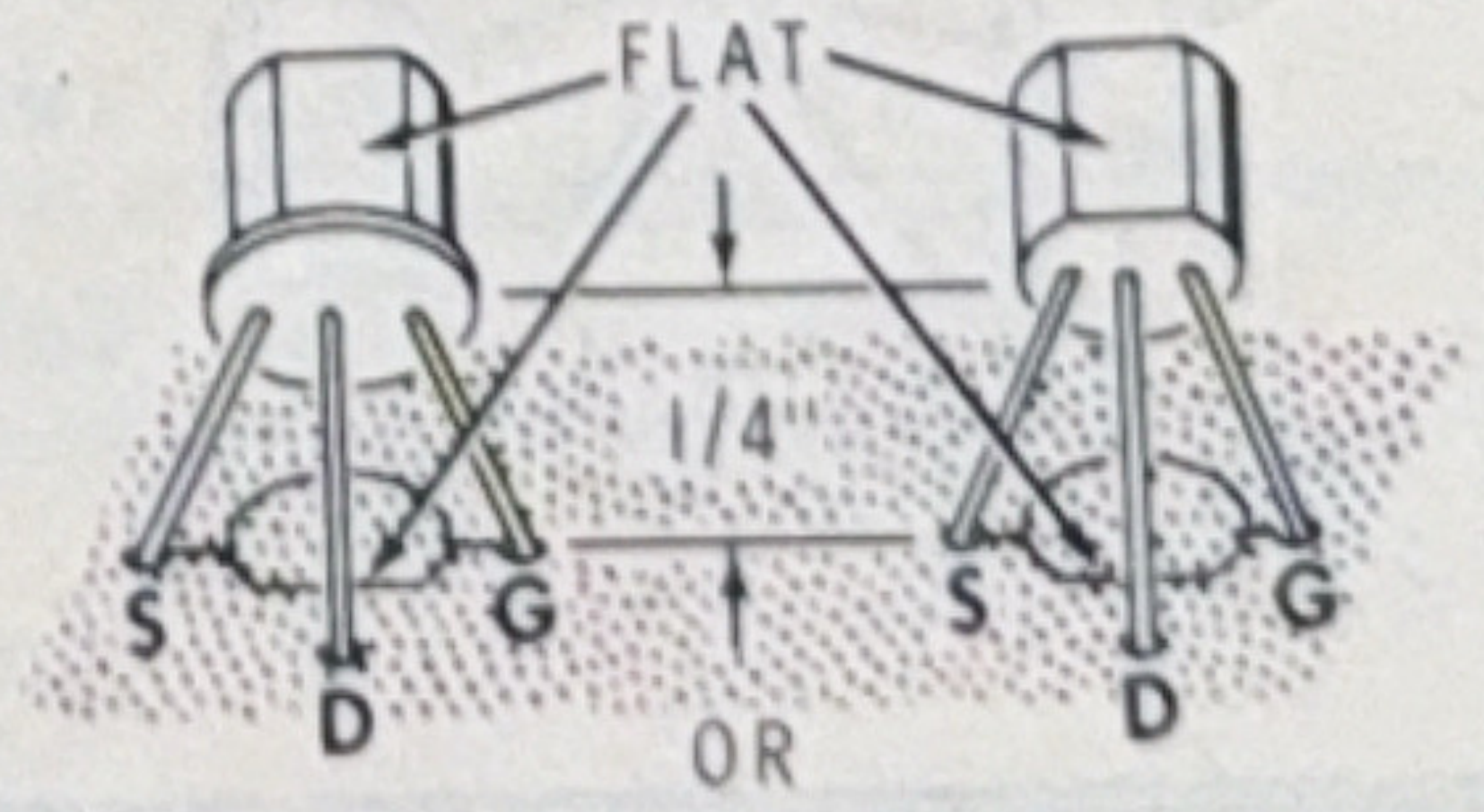
(✓) MPSA42 transistor (#417-294) at Q14.

(✓) MPS6520 transistor (#417-134) at Q15.

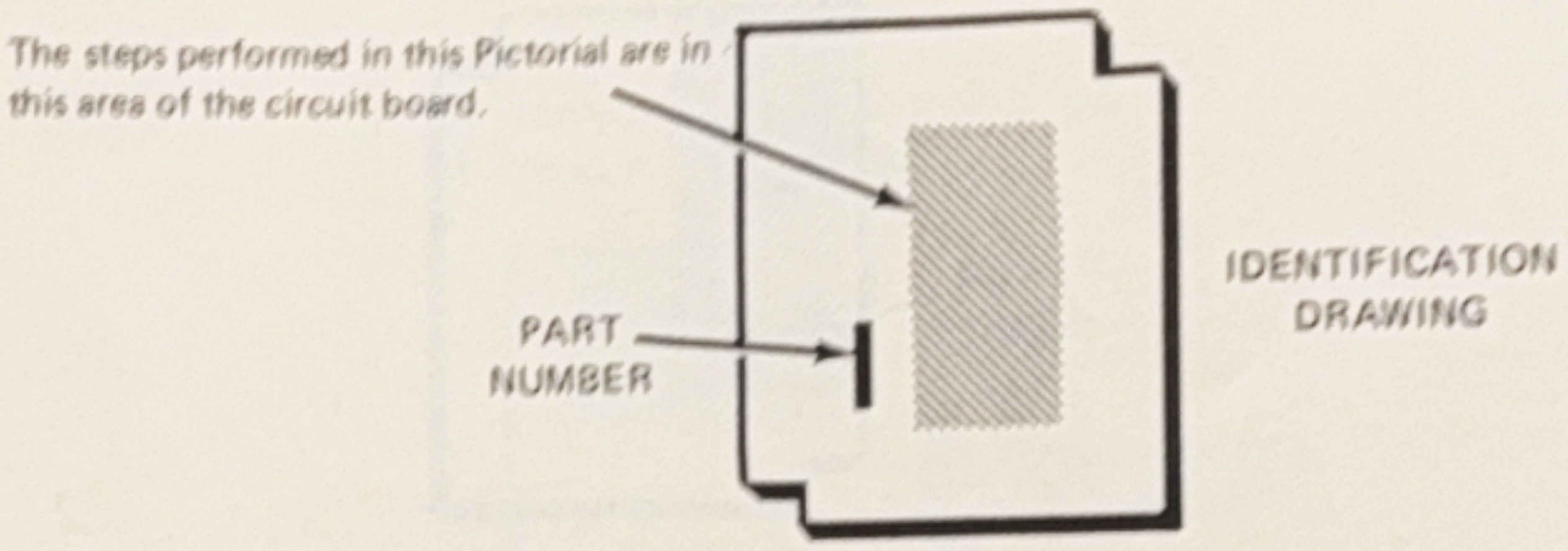
(✓) 2N3638A transistor (#417-234) at Q4.

(✓) MPSA20 transistor (#417-801) at Q3.

(✓) EL131 transistor (#417-241) at Q7.

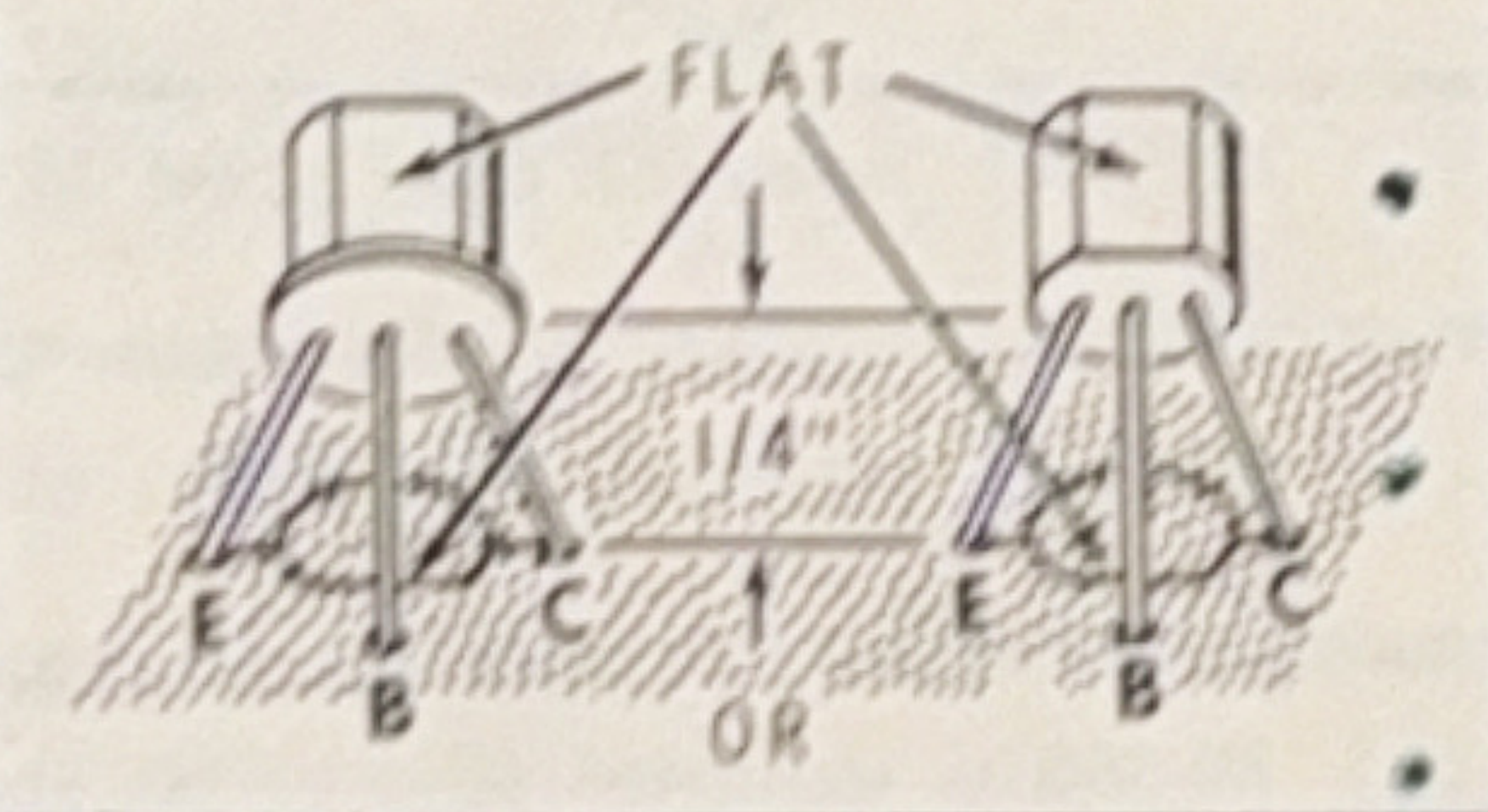


PICTORIAL 2-1


The steps performed in this Pictorial are in this area of the circuit board.
PART NUMBER
IDENTIFICATION DRAWING

START

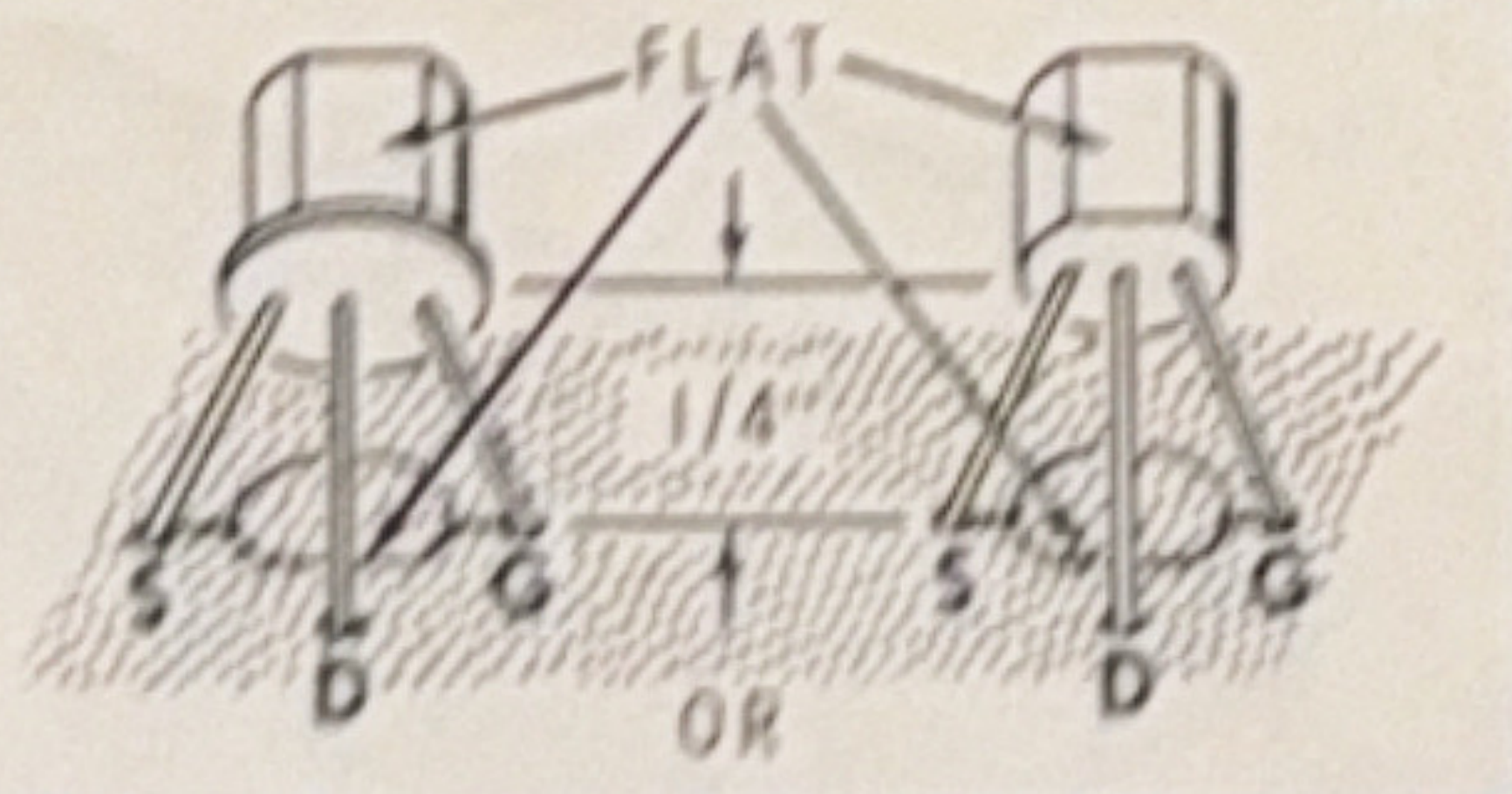
NOTE: Install each of the following transistors as shown. Solder each lead to the foil and cut off the excess lead lengths.



(✓) MPS6520 transistor (#417-134) at Q16.

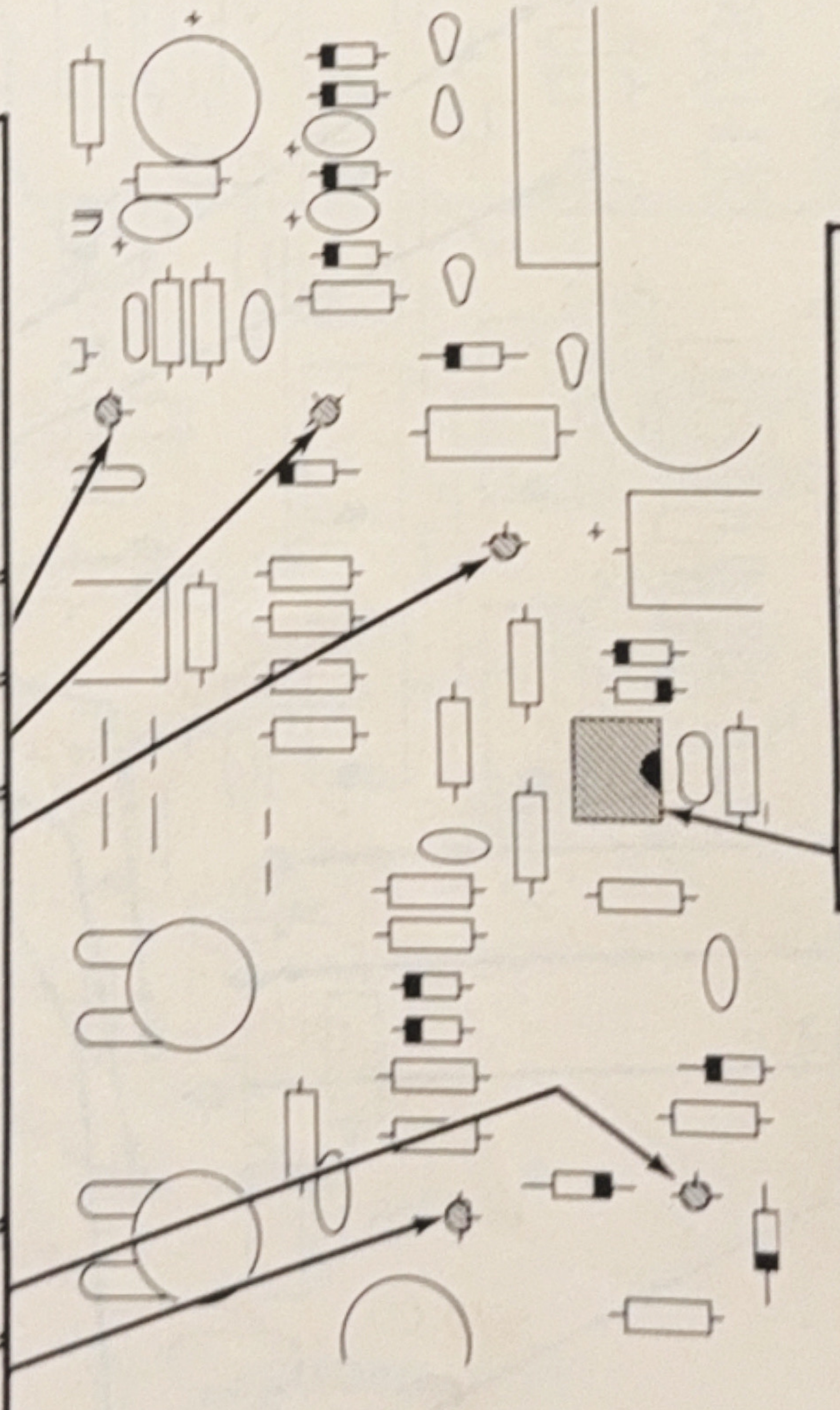
(✓) MPS6520 transistor (#417-134) at Q12.

(✓) 2N5458 transistor (#417-291) at Q8.



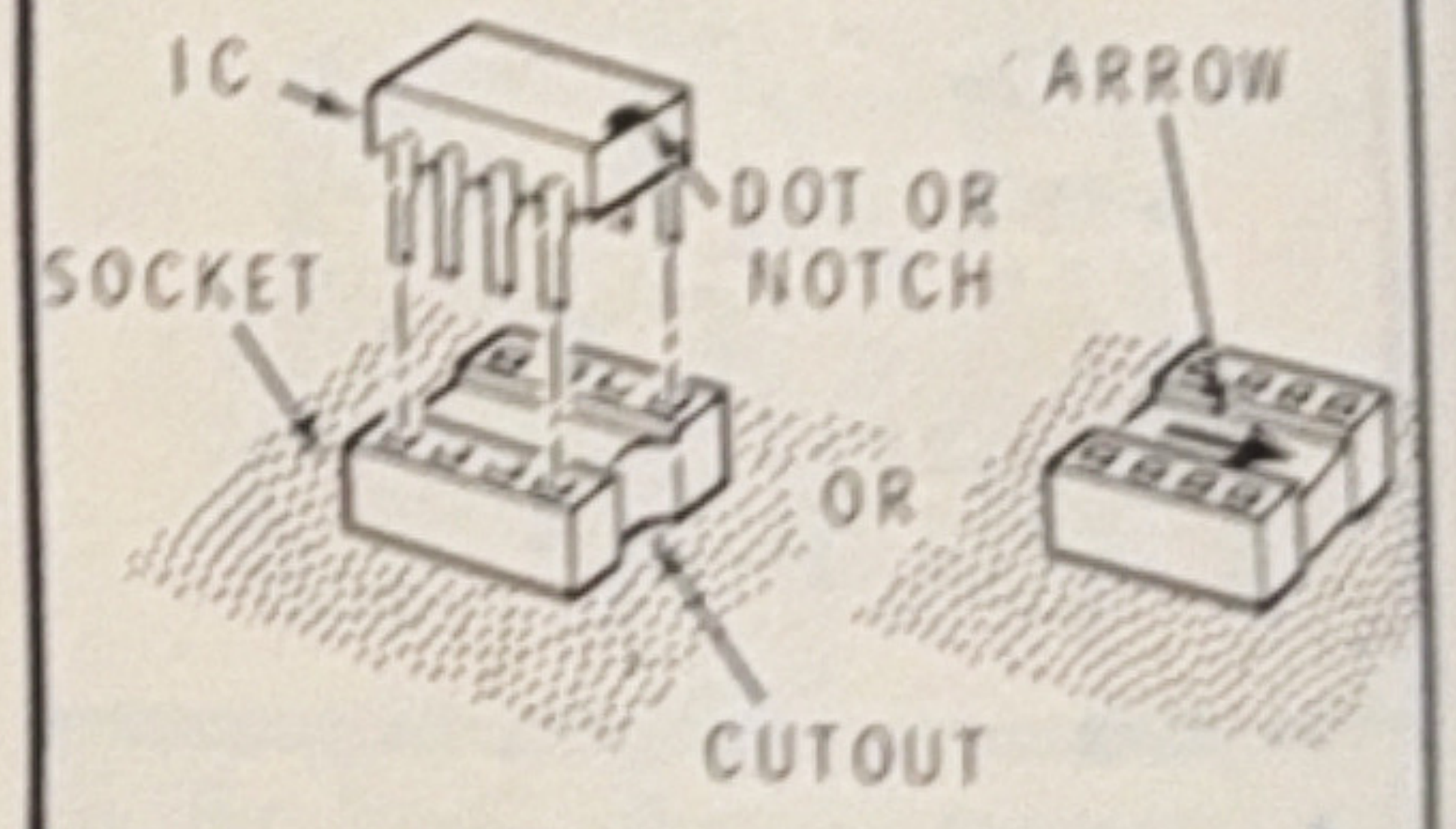
(✓) 2N3638A transistor (#417-234) at Q10.

(✓) MPSA20 transistor (#417-801) at Q9.



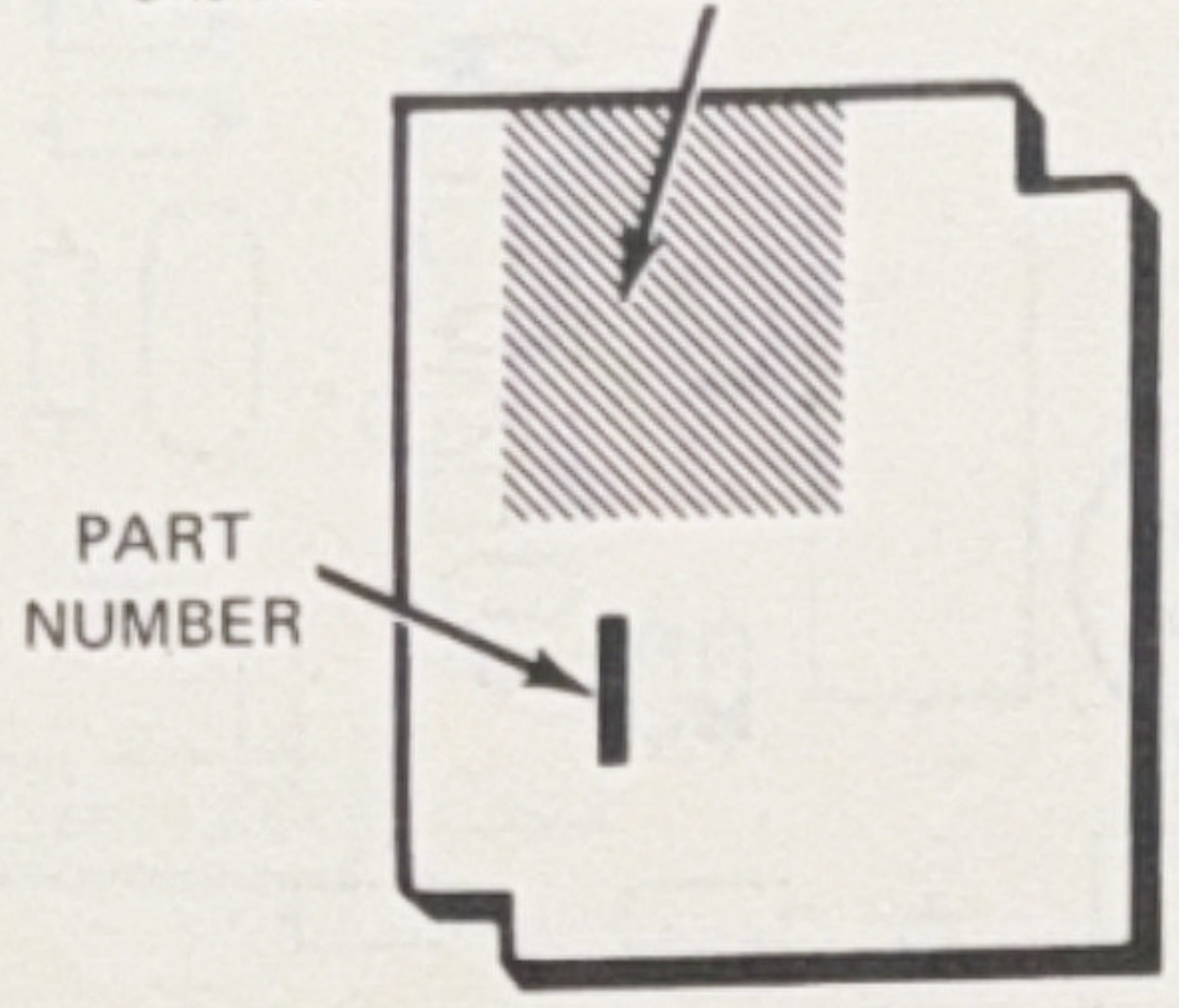
CONTINUE

NOTE: When you install the 8-pin IC in the following step, make sure the end marked with a dot or notch is positioned toward the cutout, or arrowhead, end of the socket.



(✓) 8-pin IC (#442-39) at IC1.

PICTORIAL 2-2

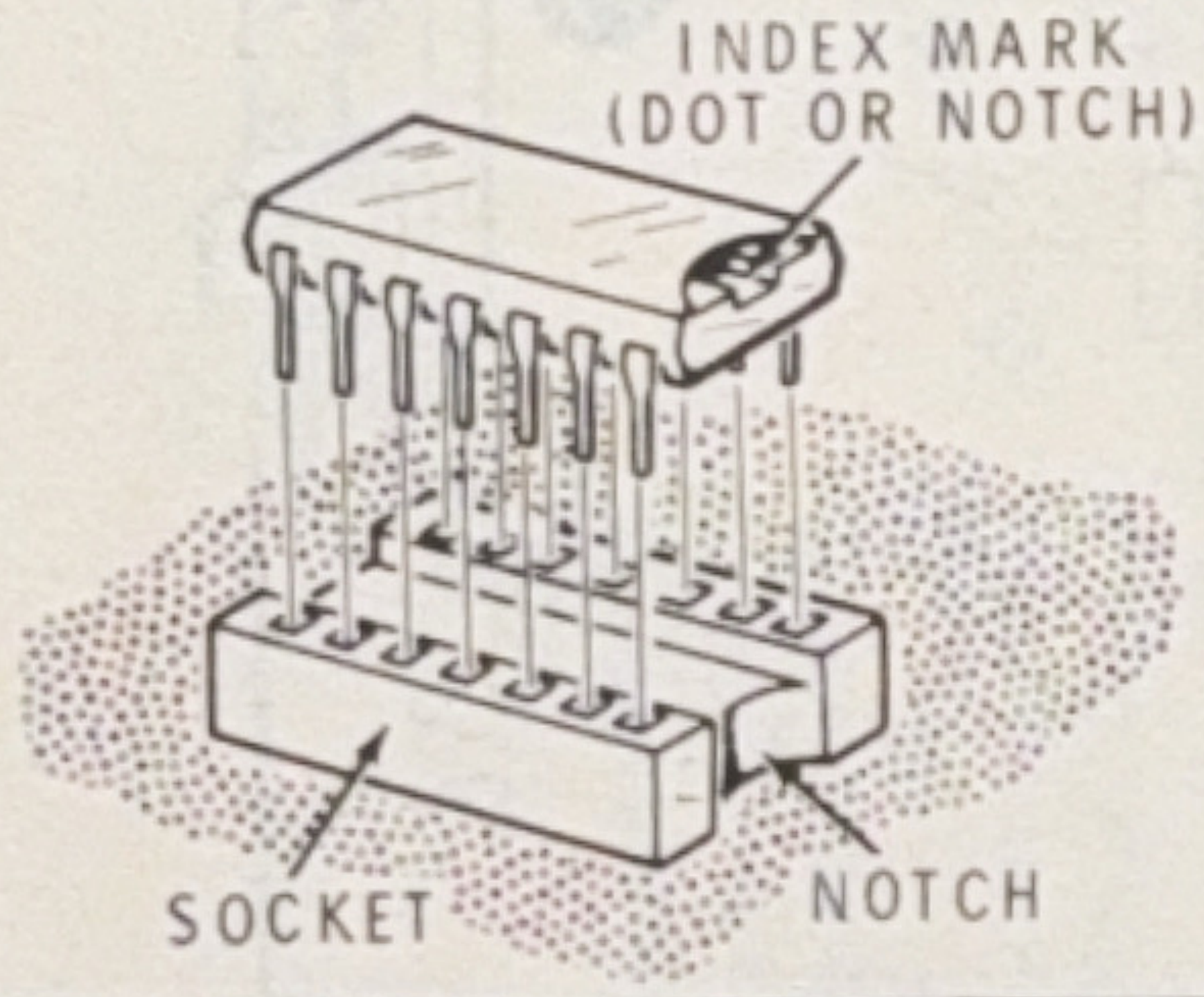

The steps performed in this Pictorial are in this area of the circuit board.
PART NUMBER

IDENTIFICATION DRAWING

START

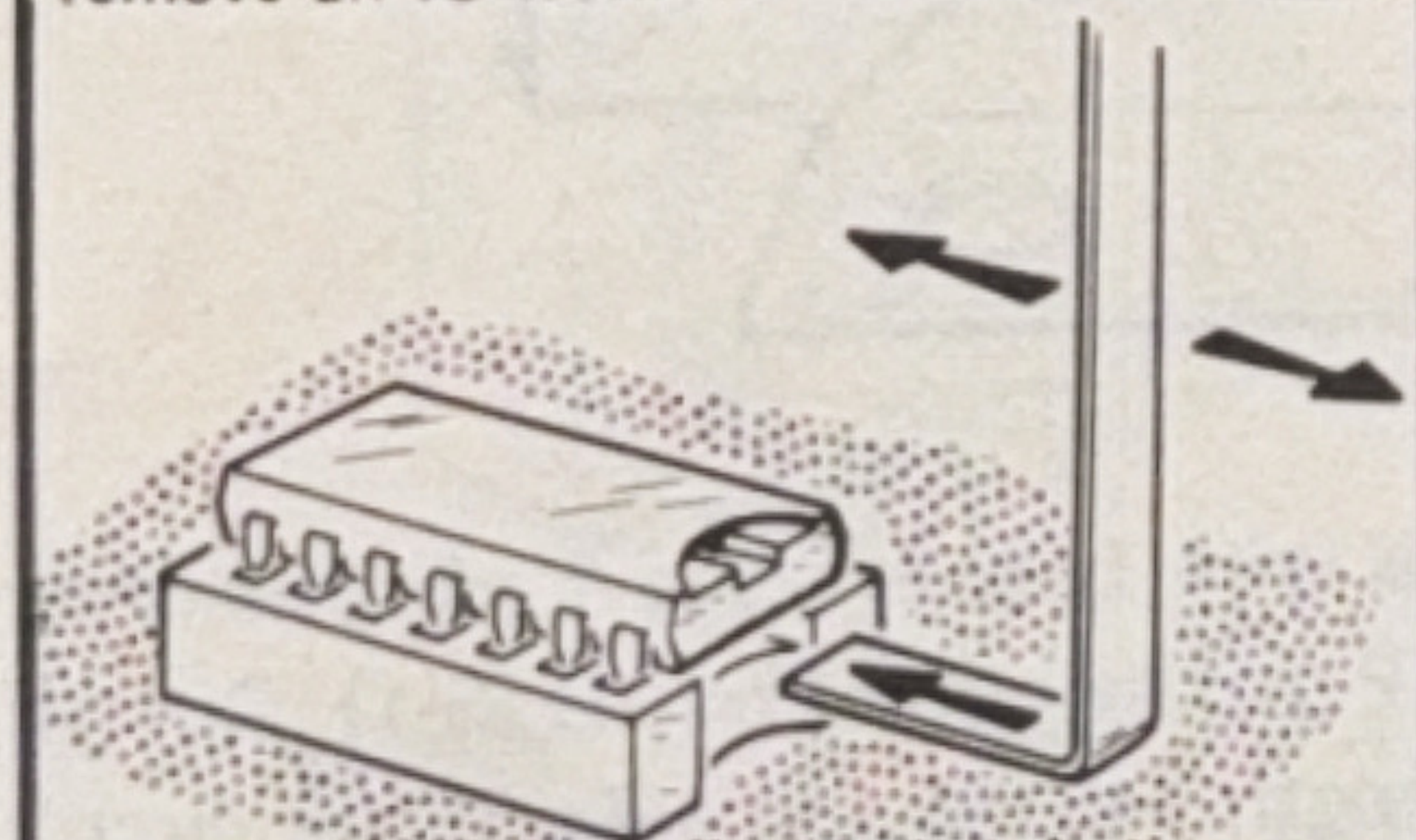
In the following steps, install IC's in the designated sockets. Be careful to match the pin 1 end of each IC to the cutout in the end of its socket. See Detail 2-3A (below).

Before you apply downward pressure to an IC, make sure each IC pin is centered in its proper socket aperture. Handle IC's with care as their pins bend very easily.


INDEX MARK (DOT OR NOTCH)
SOCKET
NOTCH

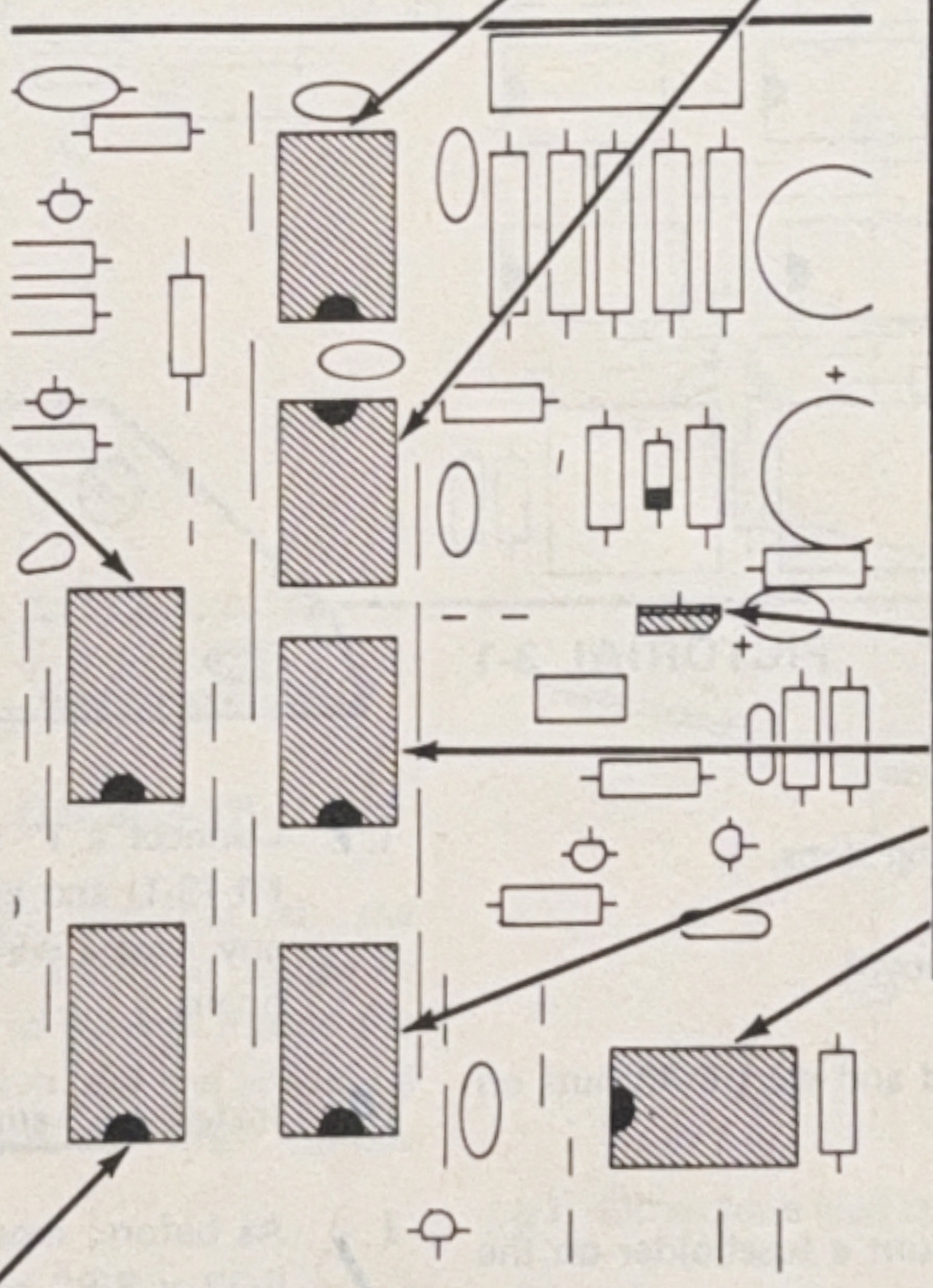
(●) 7441 IC (#443-35) at IC3.

NOTE: An IC puller has been furnished to remove an IC from its socket if necessary.



Push the shorter end of the puller in between the IC and the socket and rock the longer portion back and forth. Be very careful, as the IC pins are very easily bent.

( ) 7441 IC (#443-35) at IC4.



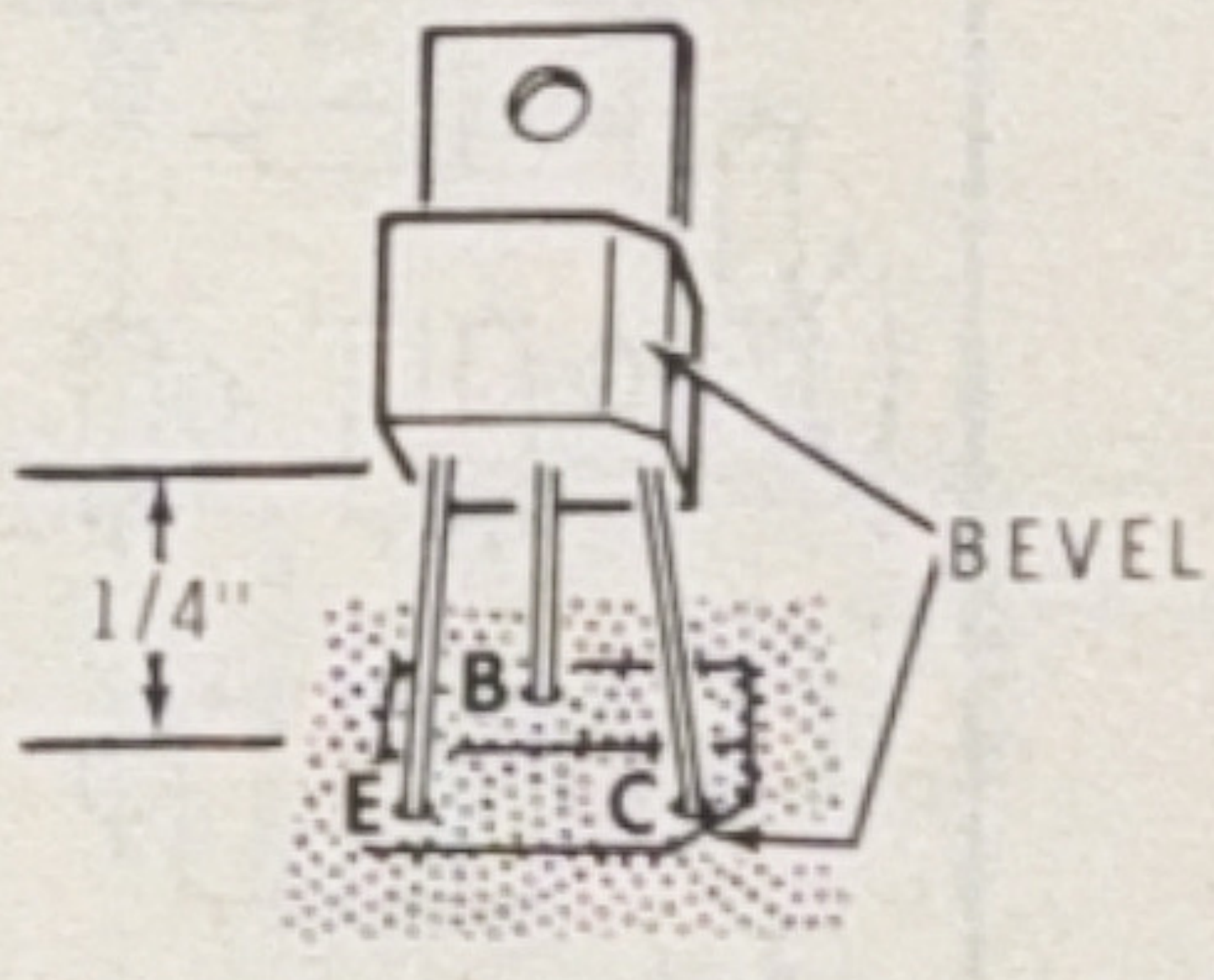
PICTORIAL 2-3

CONTINUE

(●) 7473 IC (#443-5) at IC5.

(●) 7400 IC (#443-1) at IC8. Make sure you position the marked end as shown.

NOTE: Bend the leads and install the following transistor as shown. Match the bevel on the transistor with the bevel outline on the circuit board. Solder the leads to the foil and cut off the excess lead lengths.

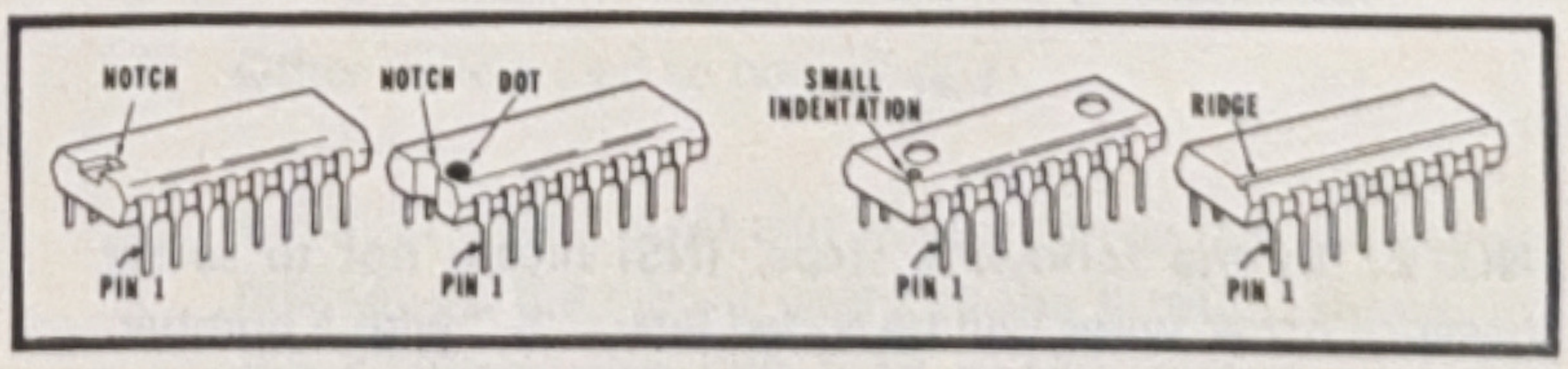


(●) D40C1 transistor (#417-272) at Q11.

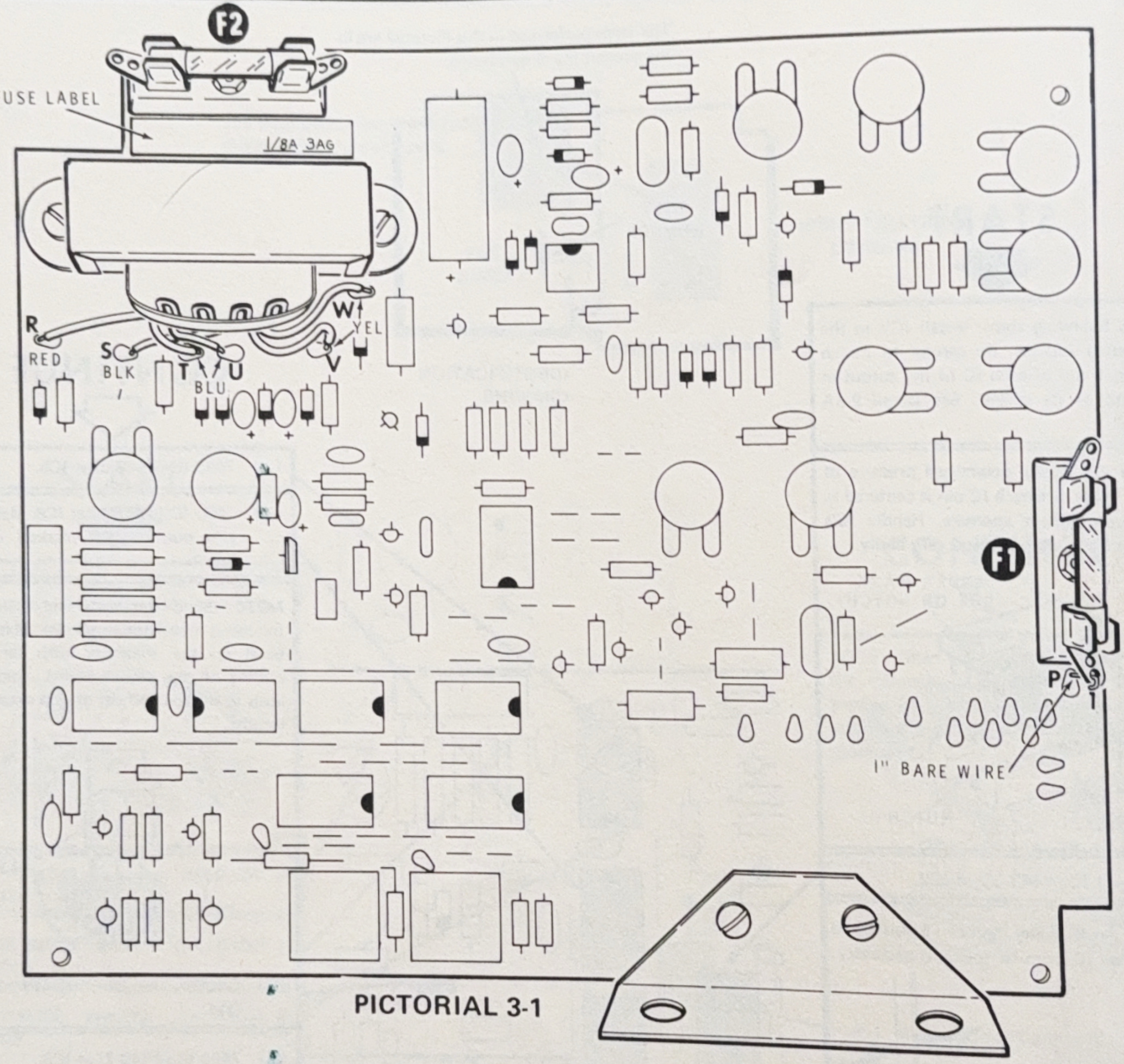
(●) 7490 IC (#443-7) at IC6.

(●) 7490 IC (#443-7) at IC7.

(●) 7402 IC (#443-46) at IC2.



Detail 2-3A



PICTORIAL 3-1

Refer to Pictorial 3-1 for the following steps.

(✓) Position the circuit board as shown.

NOTE: Use the nut starter to hold and start 6-32 nuts on screws.

(✓) Refer to Detail 3-1A and mount a fuseholder on the circuit board at F1. Use a 6-32 x 3/8" screw, two #6 lockwashers, and a 6-32 nut.

NOTE: In the following steps, (NS) means not to solder because other wires will be added later. "S-" with a number, such as (S-3), means to solder the connection. The number following the "S" tells how many wires are at the connection.

(✓) Connect a 1" bare wire between lug 1 of fuseholder F1 (S-1) and hole P on the circuit board (S-1). Cut off any excess wire length on the foil side of the circuit board.

(✓) Install the 3-ampere fuse in fuseholder F1.

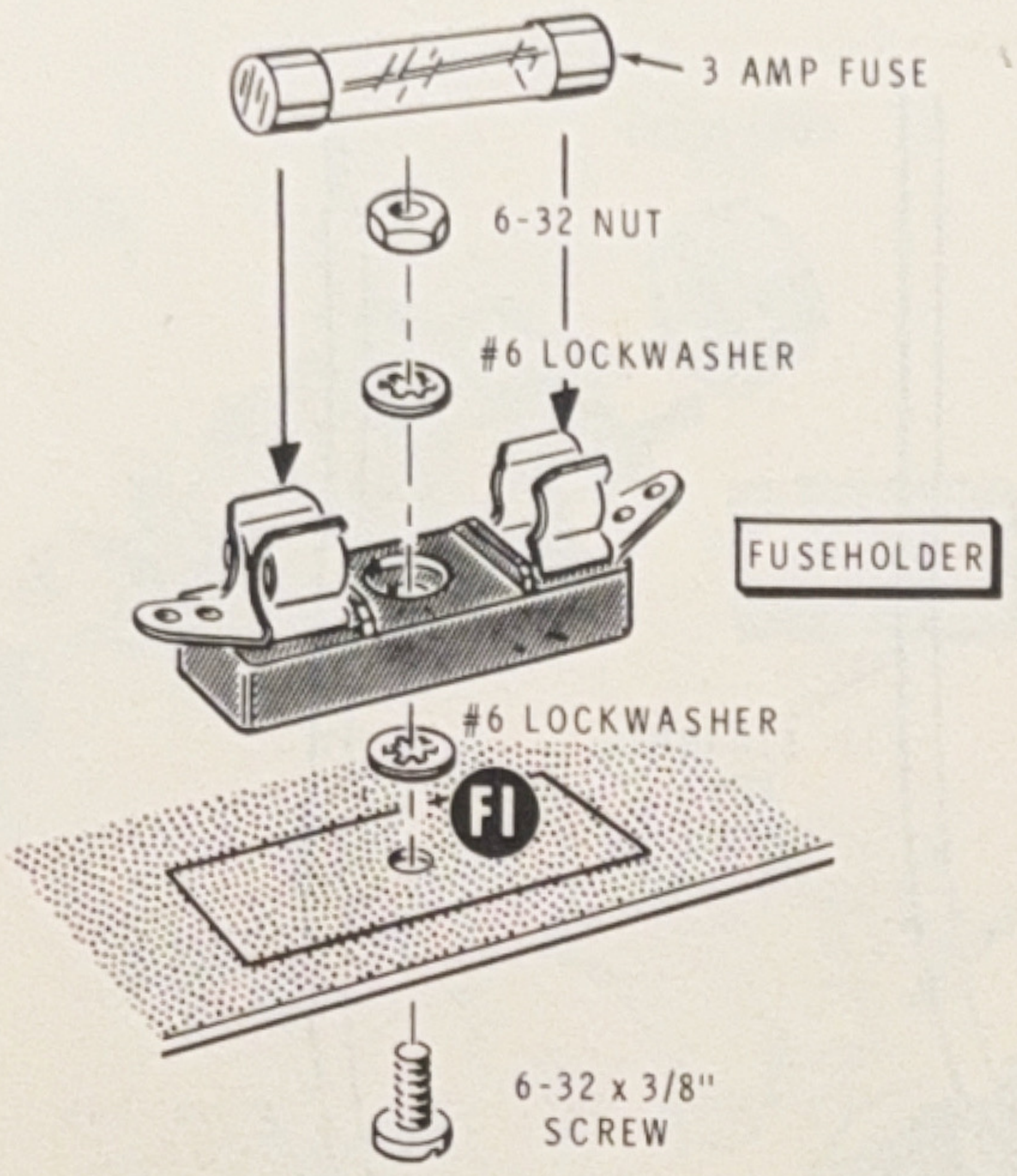
(✓) As before, mount the other fuseholder at F2. Use a 6-32 x 3/8" screw, two #6 lockwashers, and a 6-32 nut.

NOTE: In the following steps, disregard the "3AG 1/4 AMP" painted on the circuit board near fuseholder F2.

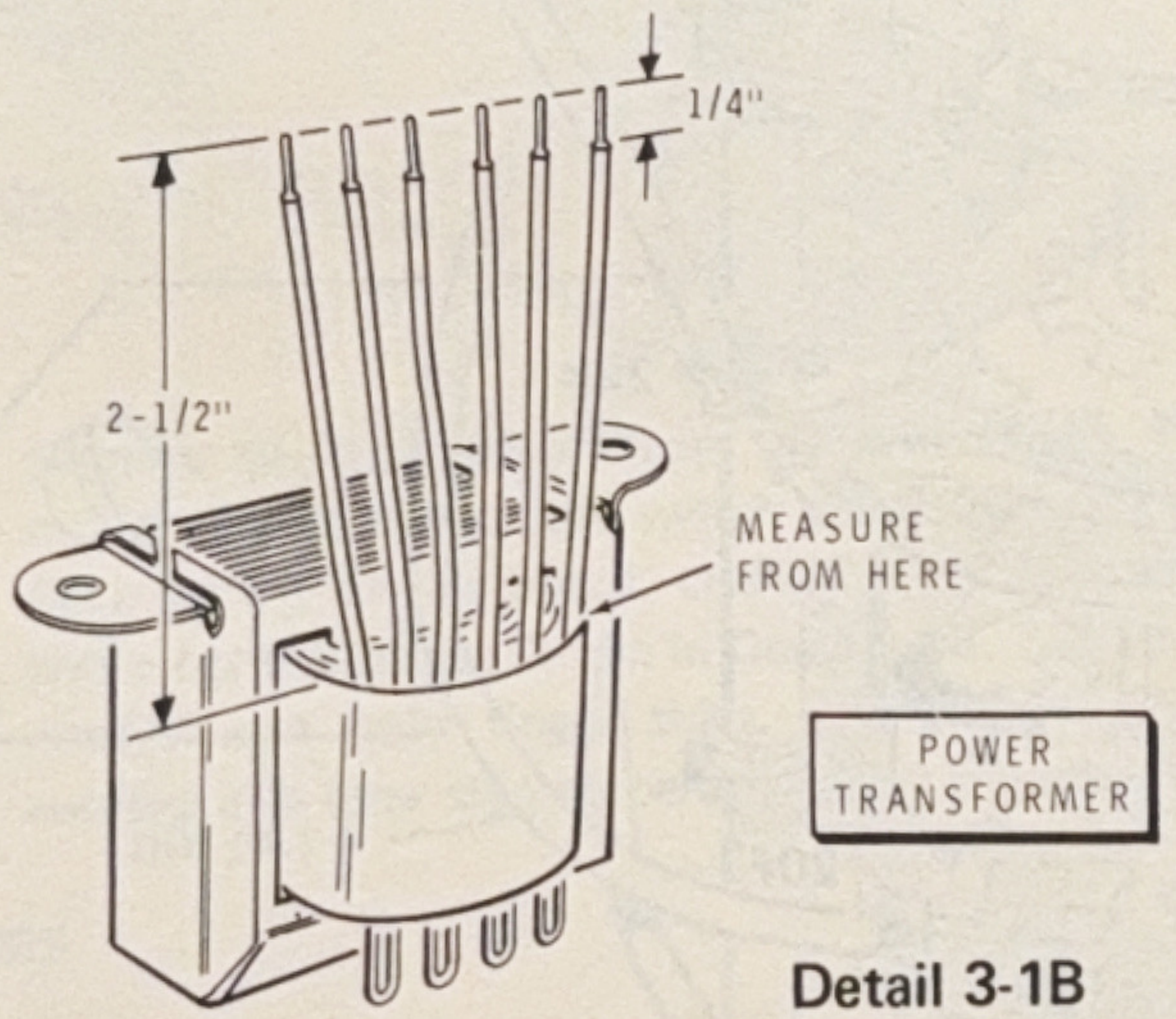
(✓) Install the 1/8-ampere fuse in fuseholder F2.

(✓) Write "1/8 A, 3AG" in the space provided on the fuse label.

(✓) Remove the paper backing from the fuse label and press it in place on the circuit board as shown in the Pictorial.



Detail 3-1A



Detail 3-1B

(✓) Locate the power transformer and cut all the transformer leads to a length of 2-1/2" as shown in Detail 3-1B. Then remove 1/4" of insulation from the end of each lead. Tightly twist each lead end and add a small amount of solder to hold the small strands together.

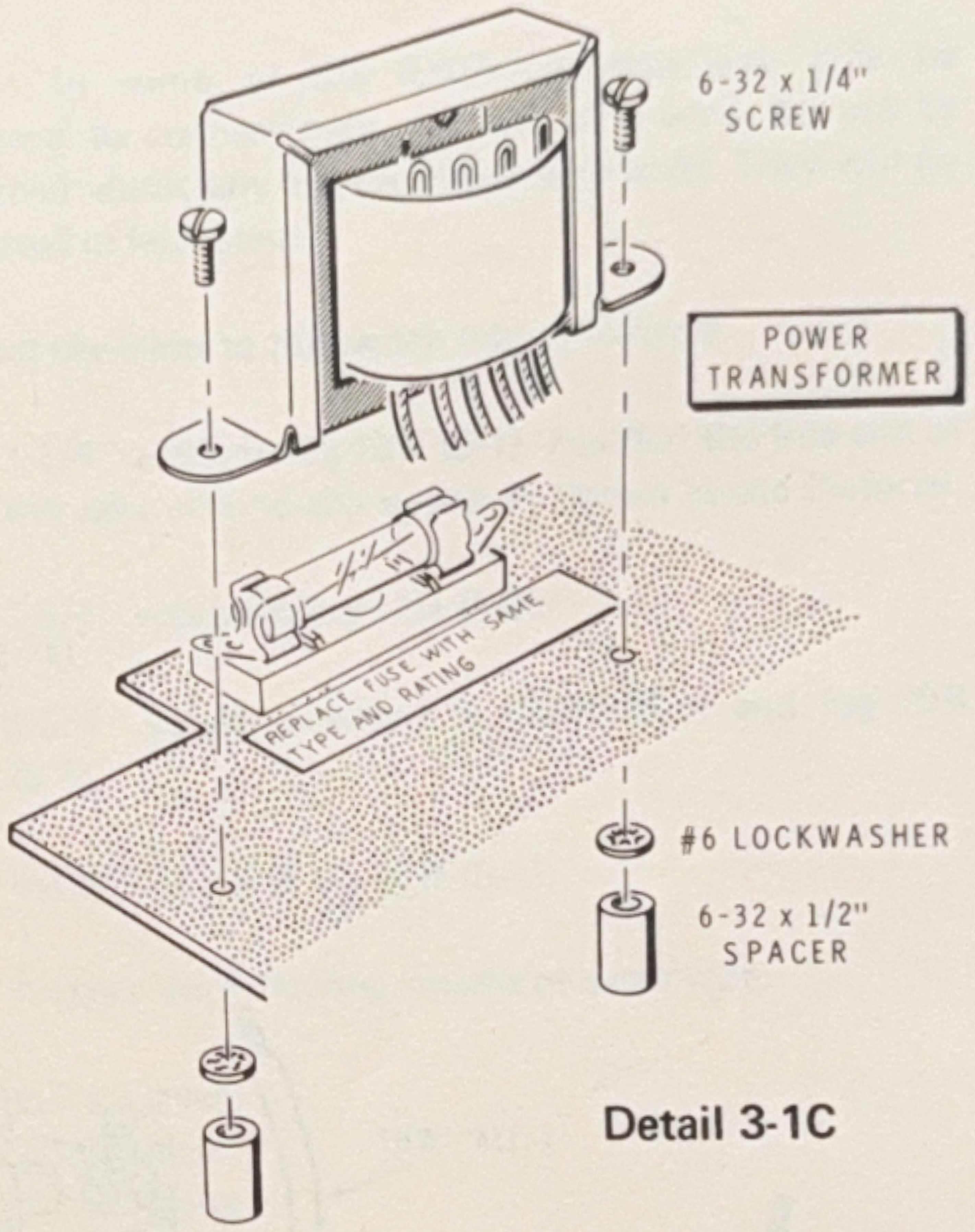
(✓) Mount the transformer on the circuit board as shown in Detail 3-1C. Use two 6-32 x 1/4" screws, two #6 lockwashers and two 6-32 x 1/2" spacers.

Connect the transformer leads to the circuit board as follows:

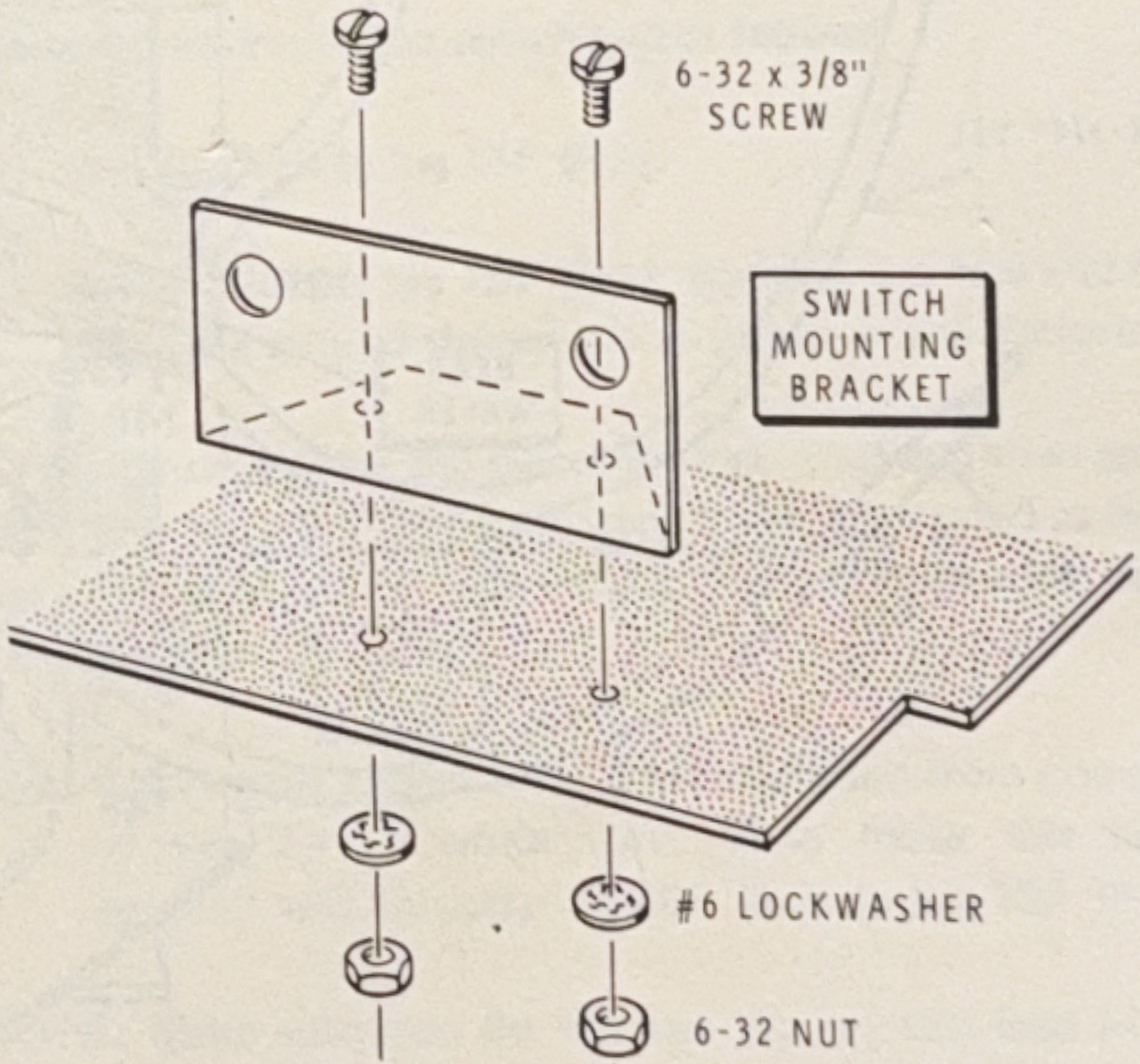
(✓) Red lead to hole R (S-1).

(✓) Black lead to hole S (S-1).

(✓) Either blue lead to hole T (S-1).



Detail 3-1C



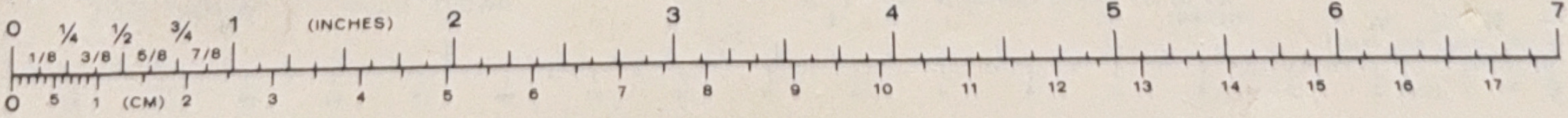
Detail 3-1D

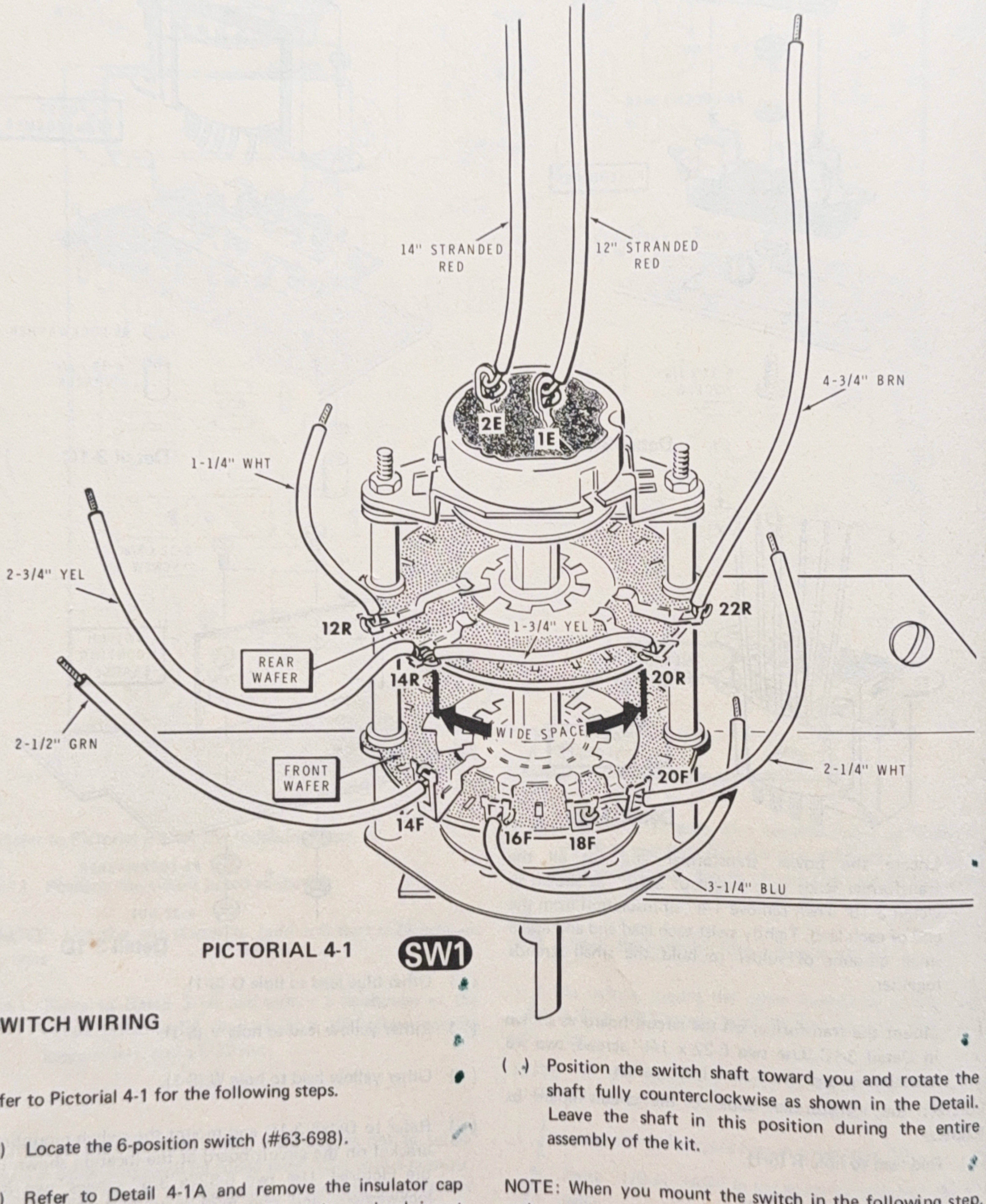
(✓) Other blue lead to hole U (S-1).

(✓) Either yellow lead to hole V (S-1).

(✓) Other yellow lead to hole W (S-1).

(✓) Refer to Detail 3-1D and mount the switch mounting bracket on the circuit board at the location shown in the Pictorial. Use two 6-32 x 3/8" screws, two #6 lockwashers, and two 6-32 nuts. Push the bracket forward as far as possible, toward the edge of the circuit board; then tighten the hardware.





PICTORIAL 4-1 **SW1**

SWITCH WIRING

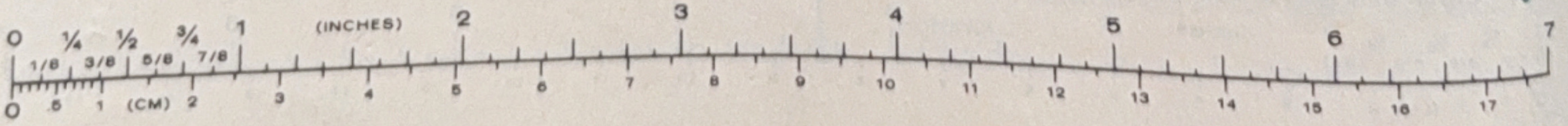
Refer to Pictorial 4-1 for the following steps.

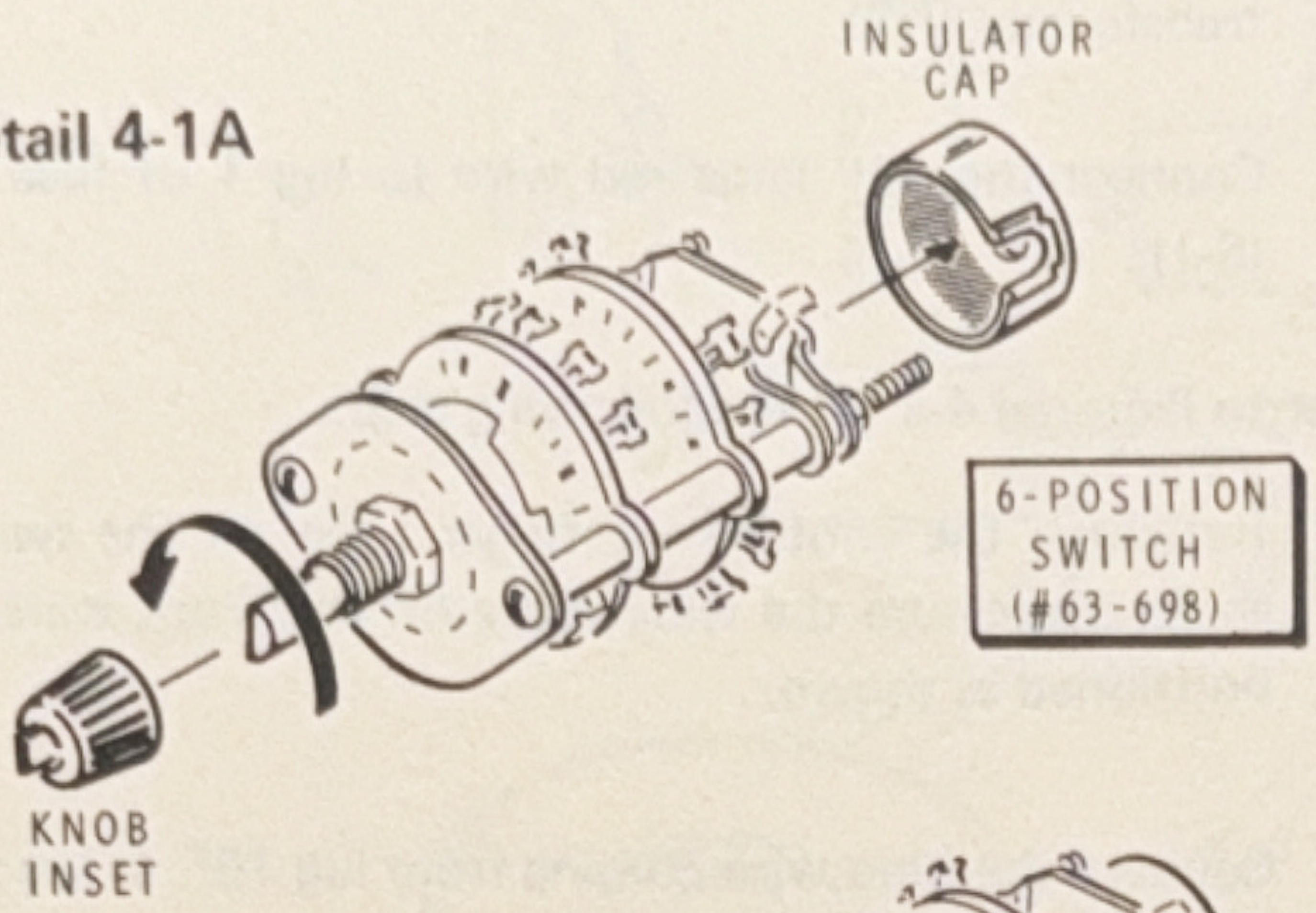
( ) Locate the 6-position switch (#63-698).

( ) Refer to Detail 4-1A and remove the insulator cap from the rear of the switch. Then place a knob insert on the switch shaft.

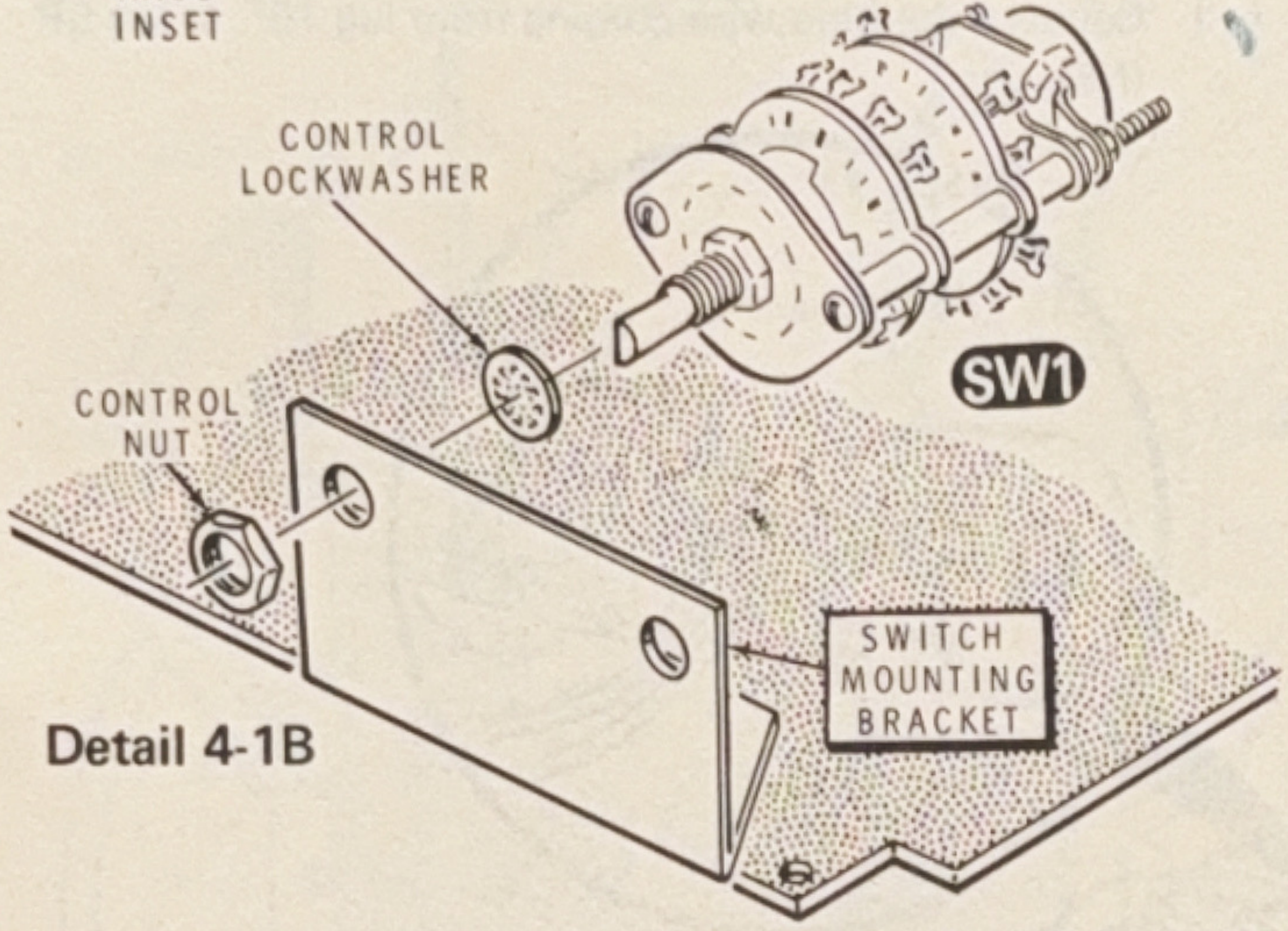
( ) Position the switch shaft toward you and rotate the shaft fully counterclockwise as shown in the Detail. Leave the shaft in this position during the entire assembly of the kit.

NOTE: When you mount the switch in the following step, make sure the wafer lugs and the wide space on the rear wafer are positioned as shown in Pictorial 4-1.





Detail 4-1A



Detail 4-1B

( ) Remove the knob insert from the switch shaft. Then mount the switch to the switch mounting bracket at SW1 on the circuit board. Use a control lockwasher and a control nut as shown in Detail 4-1B. Tighten the control nut only finger tight. The switch will be rotated in a later step to permit wiring the other side.

NOTES:

1. The lugs of switch SW1 are numbered in a clockwise direction as viewed from the front. Each possible lug location is numbered even though every hole does not have a lug. The two wafers are designated as F (front) and R (rear) as viewed from the front of the switch.

2. When wiring this kit, you will be instructed to prepare lengths of wire ahead of time, as in the next step. To prepare a wire, cut it to the length specified in the step and remove 1/4" of insulation from each end. The wires are listed in the order in which they will be used. Use only solid wire unless stranded wire is specifically called for in the step.

( ) Prepare the following lengths of solid wire:

1-1/4" white
2-3/4" yellow
1-3/4" yellow
4-3/4" brown

NOTE: In some of the following steps you may be instructed to connect only one end of a wire. Do not be concerned about any unconnected wire ends. They will be connected in later steps.

Connect the wires to the switch lugs as follows:

( ) 1-1/4" white to lug 12R (S-1). Position the free end of this wire around the switch as shown in the Pictorial.

( ) 2-3/4" yellow to lug 14R (NS).

( ) 1-3/4" yellow between lug 14R (S-2) and lug 20R (S-1).

( ) 4-3/4" brown to lug 22R (S-1).

( ) Prepare the following lengths of small wire:

2-1/2" green
3-1/4" blue
2-1/4" white

Connect the wires to the switch lugs as follows:

( ) 2-1/2" green to lug 14F (S-1).

( ) 3-1/4" blue to lug 16F (S-1). Position the free end of this wire around the switch as shown in the Pictorial.

NOTE: Where a wire end passes through a lug and then goes elsewhere, as in the following step, it will be treated as two wires in the soldering instructions (S-2), one entering and one leaving the lug.

( ) Remove an additional 3/8" of insulation from one end of the 2-1/4" white wire. Then route this 5/8" stripped end through lug 20F (S-2) to lug 18F (S-1).

NOTE: Make sure you do not use the red test lead in the following step. The red test lead is longer and more flexible than the stranded red wire.

( ) Prepare the following lengths of stranded wire:

14" stranded red
12" stranded red

NOTE: In the next two steps, wrap the wire ends firmly around the switch lugs to assure a good mechanical connection.

( ) 14" stranded red to lug 2E (S-1).

( ) 12" stranded to lug 1E (S-1).

Refer to Pictorial 4-2 for the following steps.

(✓) Loosen the control nut and turn the switch one-half turn so the other side is up.

(✓) Refer to inset drawing #1 and replace the insulator cap on the switch. Route the red stranded wires through the "U" shaped opening in the cap as shown.

( ) Insert both red stranded wires down through hole R in the circuit board and route them underneath as indicated by the dashed lines in the Pictorial. You may have to remove the switch from the bracket to insert the wires through hole R.

NOTE: Make mechanically secure connections in the following steps by wrapping each wire end tightly around the indicated lug as shown on inset drawing #2.

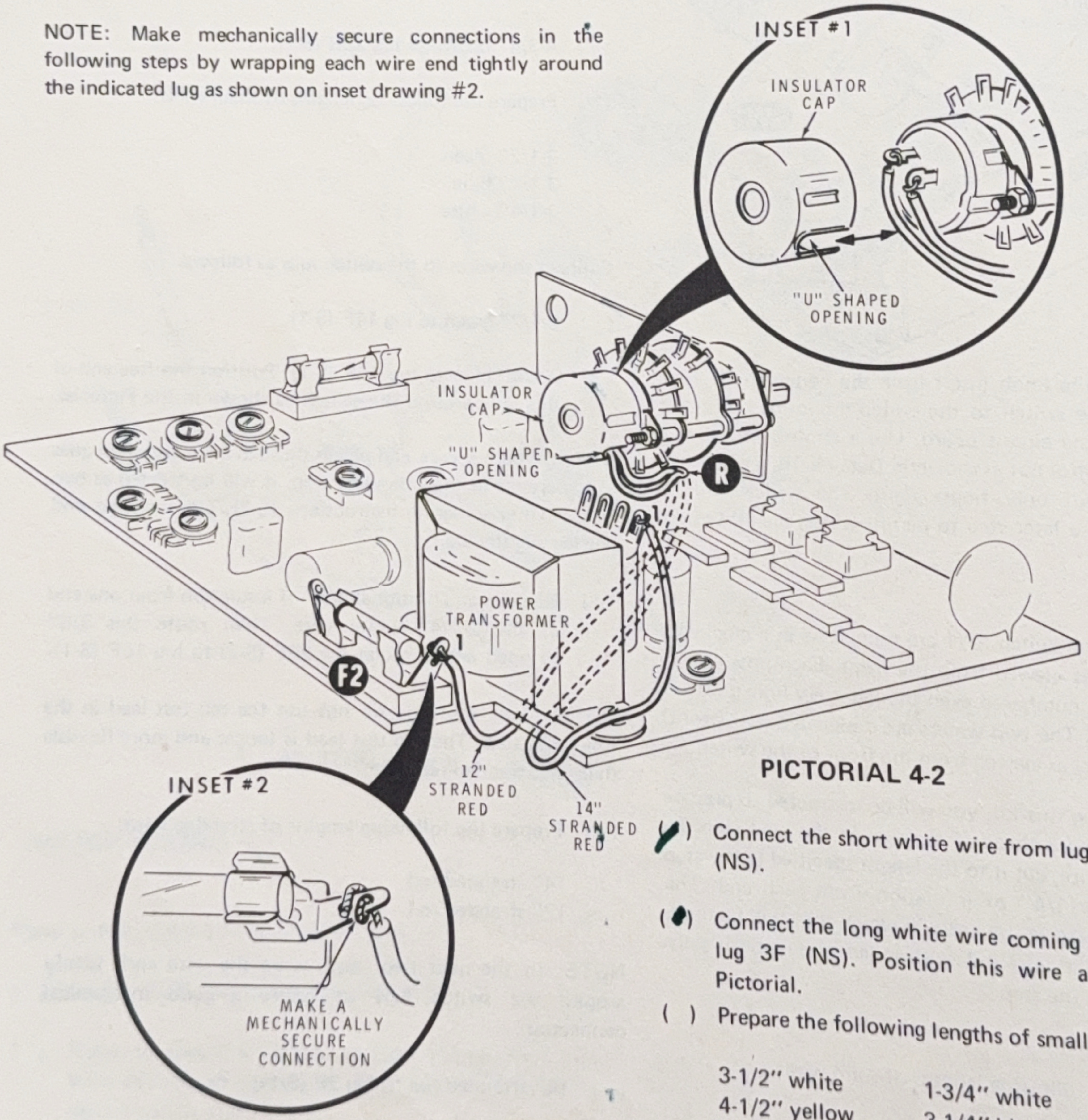
(✓) Connect the 14" large red wire to lug 1 of the power transformer (NS).

(✓) Connect the 12" large red wire to lug 1 of fuse F2 (S-1).

Refer to Pictorial 4-3 for the following steps.

(✓) Retighten the control nut finger tight on the switch shaft. Make sure the wide space on the front wafer is positioned as shown.

(✓) Connect the blue wire coming from lug 16F to lug 5R (NS).



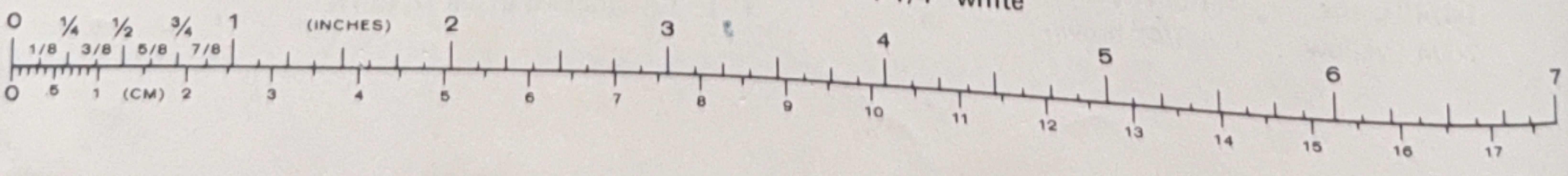
PICTORIAL 4-2

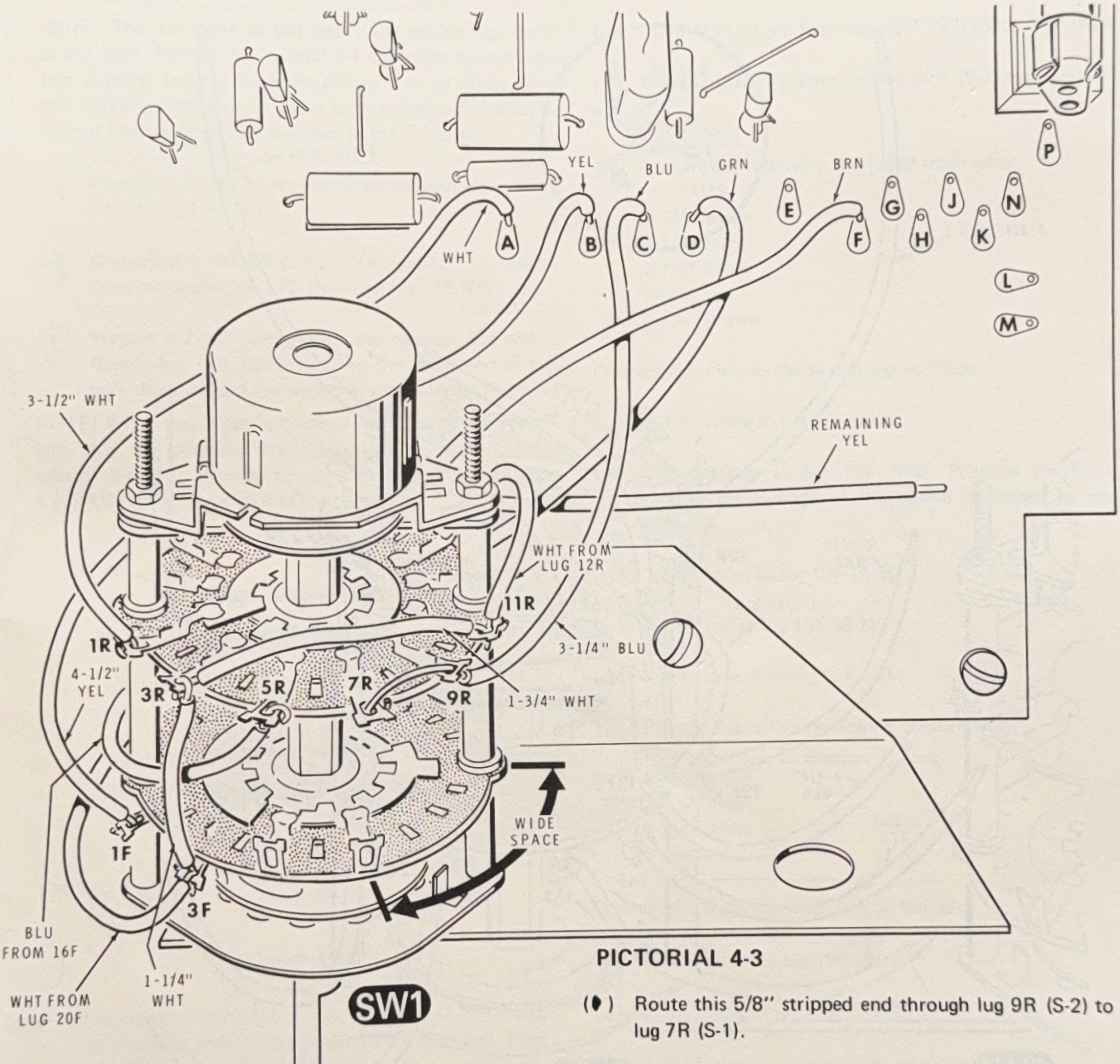
(✓) Connect the short white wire from lug 12R to lug 11R (NS).

(✓) Connect the long white wire coming from lug 20F to lug 3F (NS). Position this wire as shown in the Pictorial.

( ) Prepare the following lengths of small wire:

3-1/2" white
4-1/2" yellow
1-1/4" white
1-3/4" white
3-1/4" blue





PICTORIAL 4-3

Connect the wires to the switch lugs as follows:

(✓) 3-1/2" white to lug 1R (S-1).

(✓) 4-1/2" yellow to lug 1F (S-1).

(✓) 1-1/4" white between lug 3F (S-2) and lug 3R (NS).

(✓) 1-3/4" white between lug 3R (S-2) and lug 11R (S-2).

(✓) Remove an additional 3/8" of insulation from one end of the 3-1/4" blue wire.

(✓) Route this 5/8" stripped end through lug 9R (S-2) to lug 7R (S-1).

Connect the wires on switch SW1 to the circuit board as follows:

(✓) White to hole A (S-1).

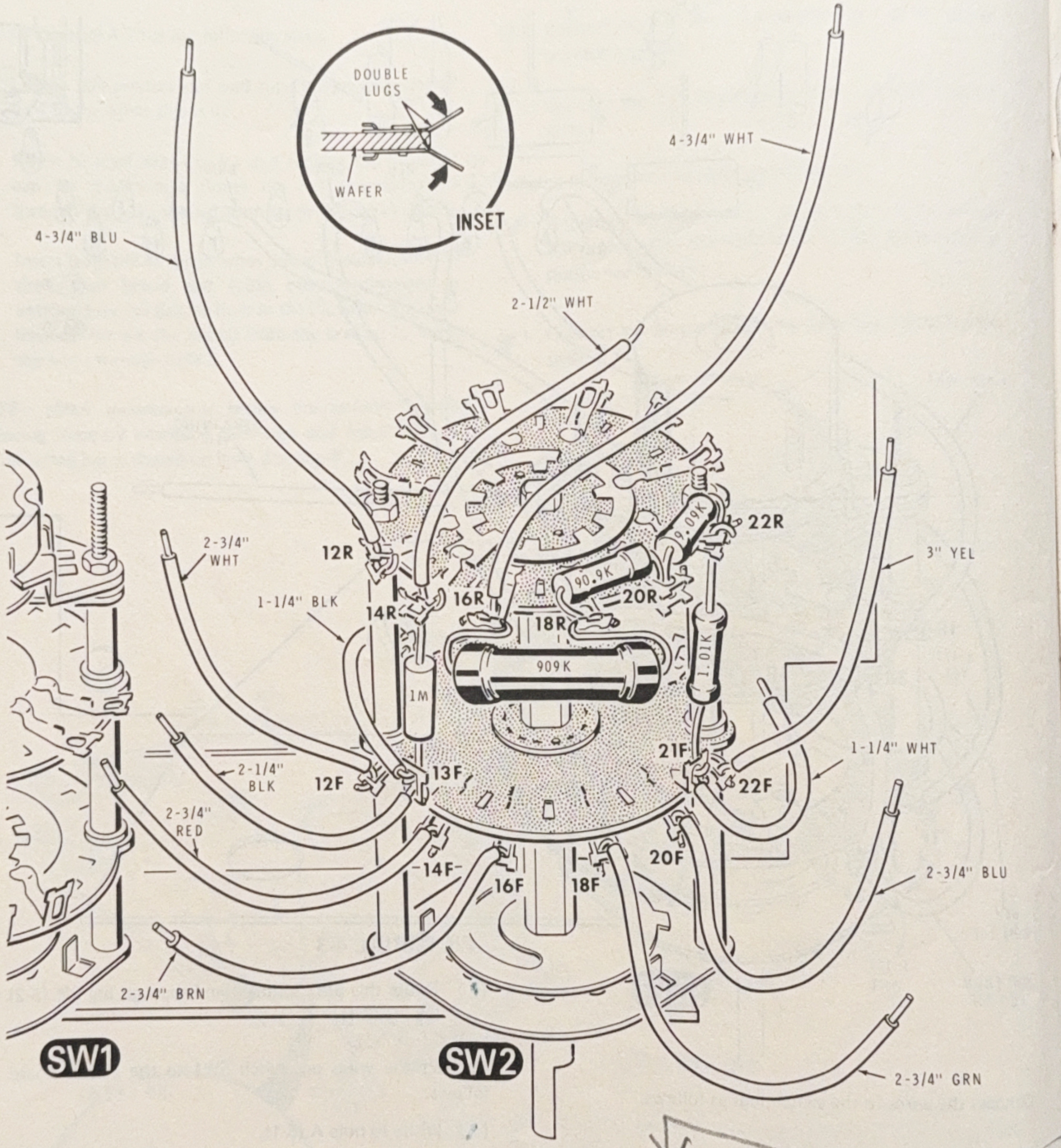
(✓) 4-1/2" yellow coming from lug 1F to hole B (S-1).

(✓) Blue to hole C (S-1).

(✓) Green to hole D (S-1).

(✓) Brown to hole F (S-1).

The remaining yellow wire will be connected later.



PICTORIAL 4-4

Refer to Pictorial 4-4 for the following steps.

(✓) Locate the 5-position switch (#63-699) and place a knob insert on the switch shaft.

(✓) Position the switch shaft toward you and rotate it fully counterclockwise. Leave the shaft in this position during the assembly of this kit.

(✓) Remove the knob insert.

(✓) Refer to Detail 4-4A and mount the 5-position switch to the switch mounting bracket at SW2. Use a control lockwasher and a control nut. Make sure the lugs on the switch are positioned as shown. NOTE: Lugs 13F and 21F are bent rearward with a wide space between them.

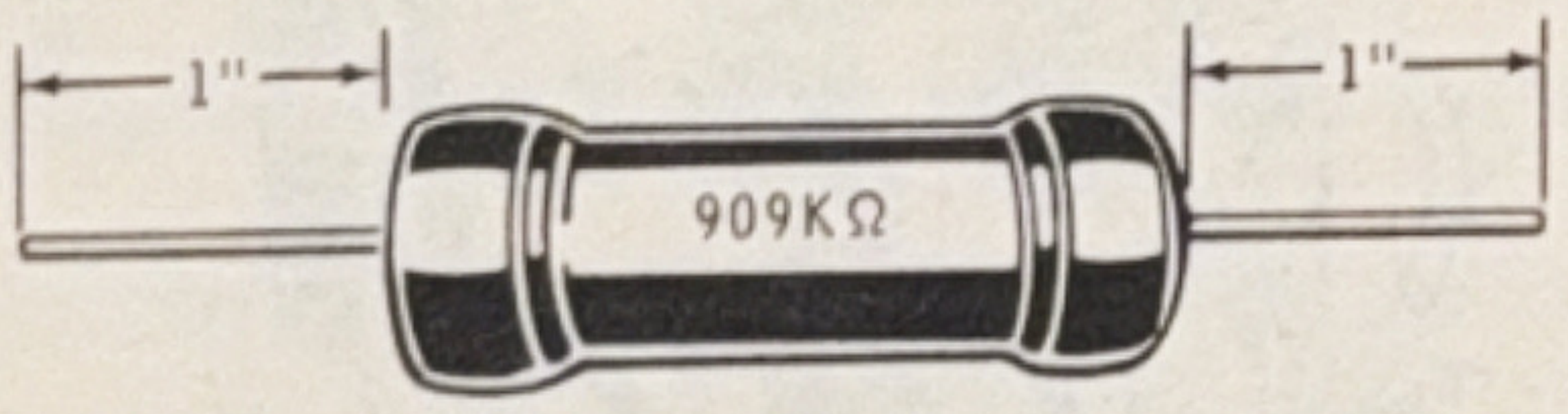
NOTE: The rear wafer of this switch has double lugs. Refer to the inset drawing on Pictorial 4-4 and press these double lugs together before you make connections to them. When you make connections to these lugs, connect the wires or resistor leads to both lugs as shown in the Pictorial.

(✓) Prepare a 4-3/4" blue wire. Then connect one end to double lug 12R (S-1).

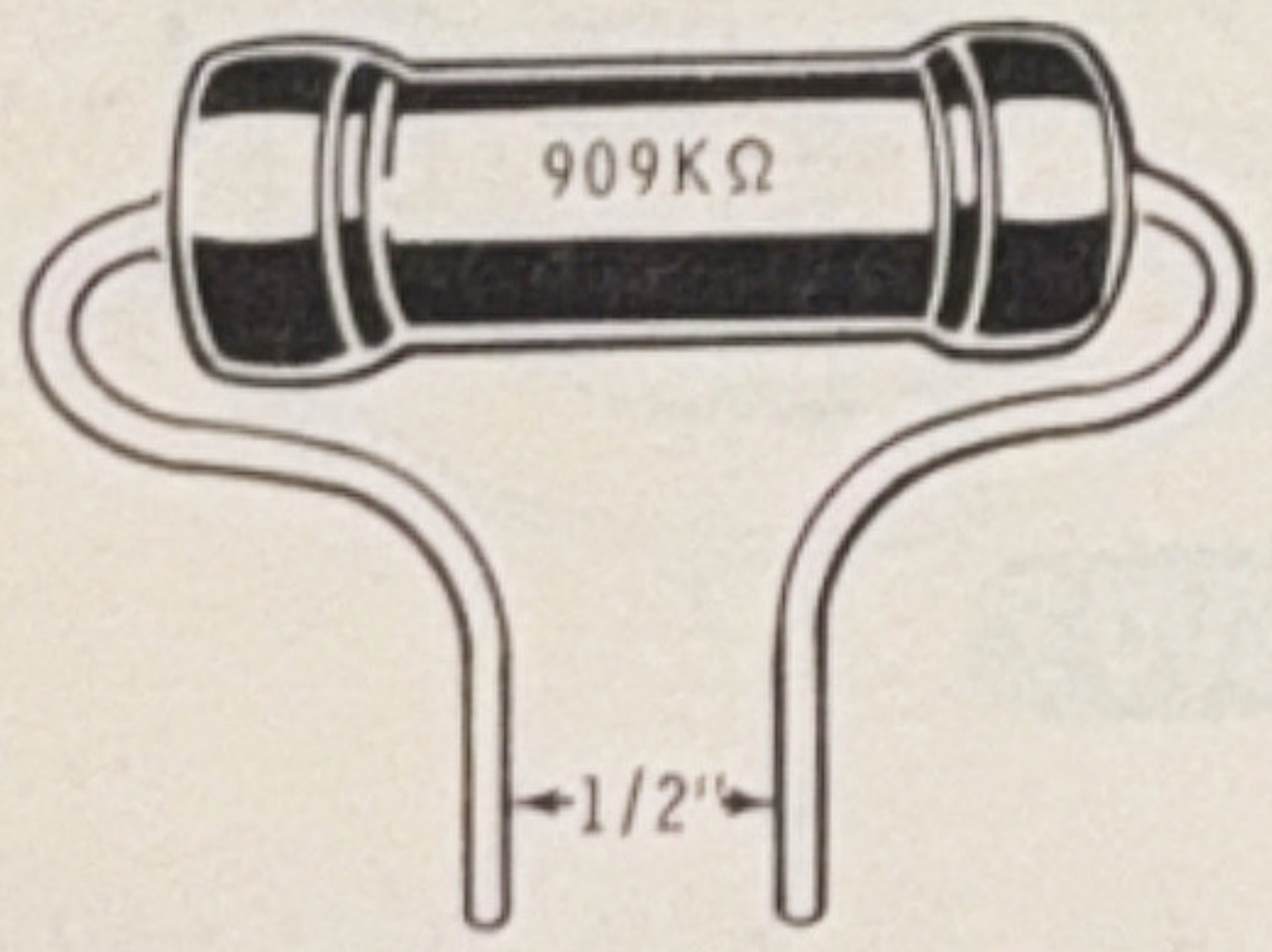
(✓) Connect a 1 MΩ, 5% (brown-black-green-gold) resistor between double lug 14R (NS) and lug 13F (NS).

(✓) Prepare a 2-1/2" white wire and connect one end to double lug 14R (S-2). Position the other end of this wire down behind the switch as shown in the Pictorial.

NOTE: When you connect precision resistors to the switch lugs, as in the following steps, make sure you identify each resistor correctly. It might be easy, for example, to mistake a 909 kΩ resistor for a 90.9 kΩ resistor.



Detail 4-4B



Detail 4-4C

(✓) Refer to Detail 4-4B and cut the leads of a 909 kΩ, .5% precision resistor to a length of 1" as shown. Then shape the leads as shown in Detail 4-4C.

(✓) Connect this 909 kΩ precision resistor between lug 16R (NS) and lug 18R (NS).

(✓) Prepare a 4-3/4" white wire. Then connect one end to lug 16R (S-2).

Connect precision resistors to the switch lugs as follows:

(✓) 90.9 kΩ, between lug 18R (S-2) and lug 20R (NS).

(✓) 1010 Ω (1.01 k), from lug 22R (NS) to lug 21F (NS).

(✓) 9090 Ω (9.09 k), between lug 20R (S-2) and lug 22R (S-2).

(✓) Prepare the following lengths of small wire:

2-3/4" white
1-1/4" black
2-1/4" black
2-3/4" red
2-3/4" brown

Connect the wires to the switch lugs as follows:

(✓) 2-3/4" white to lug 12F (S-1).

(✓) 1-1/4" black to lug 13F (NS). Position this wire around the outside of the switch as shown in the Pictorial.

(✓) 2-1/4" black to lug 13F (S-3).

(✓) 2-3/4" red to lug 14F (S-1).

(✓) 2-3/4" brown to lug 16F (S-1).

(✓) Prepare the following lengths of small wire:

2-3/4" green
2-3/4" blue
1-1/4" white
3" yellow

Connect the wires to switch lugs as follows:

(✓) 2-3/4" green to lug 18F (S-1).

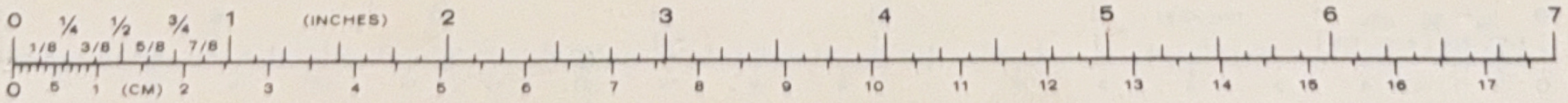
(✓) 2-3/4" blue to lug 20F (S-1).

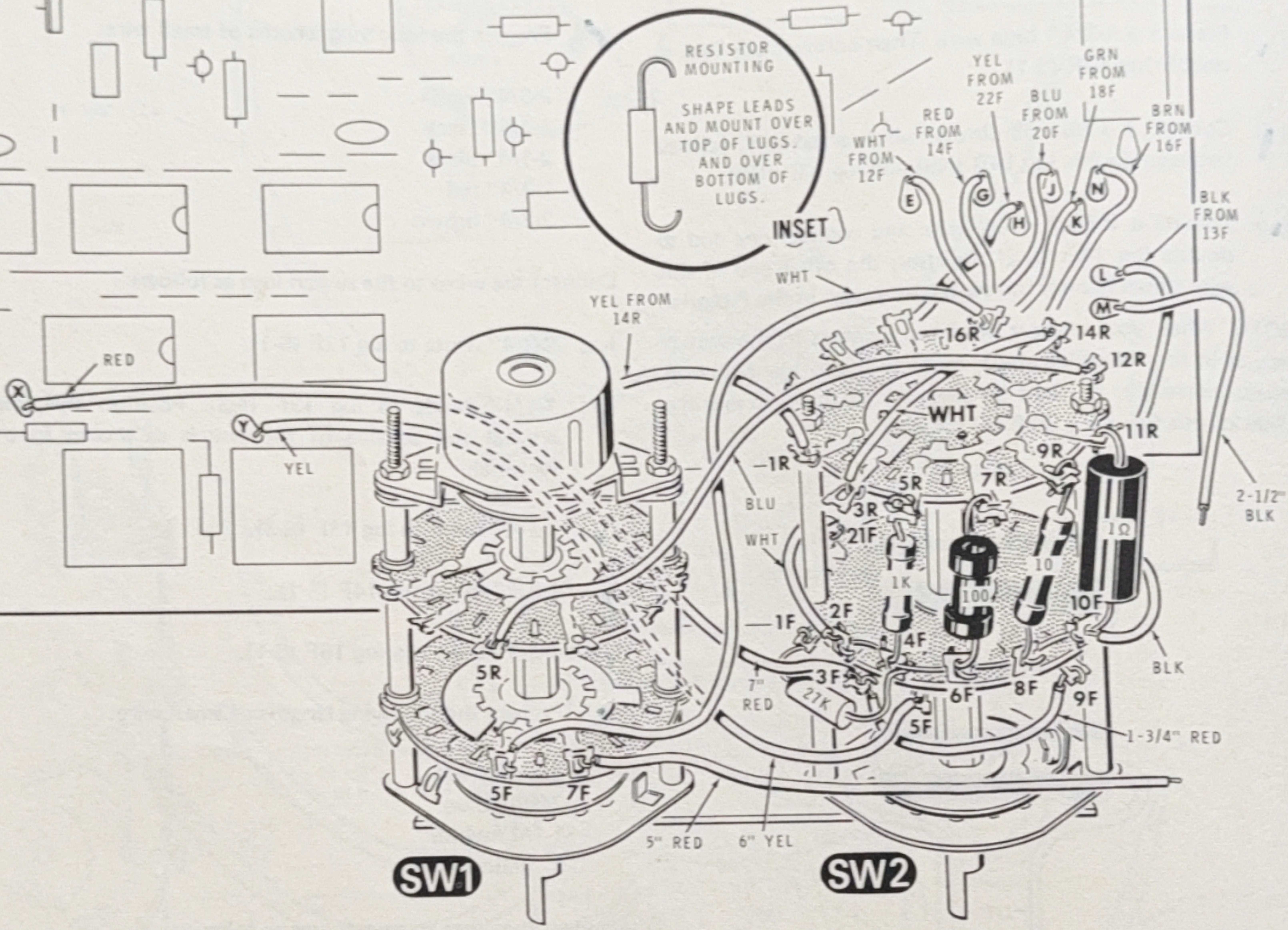
(✓) 1-1/4" white to lug 21F (S-2). Position this wire around the outside of the switch as shown in the Pictorial.

(✓) 3" yellow to lug 22F (S-1).

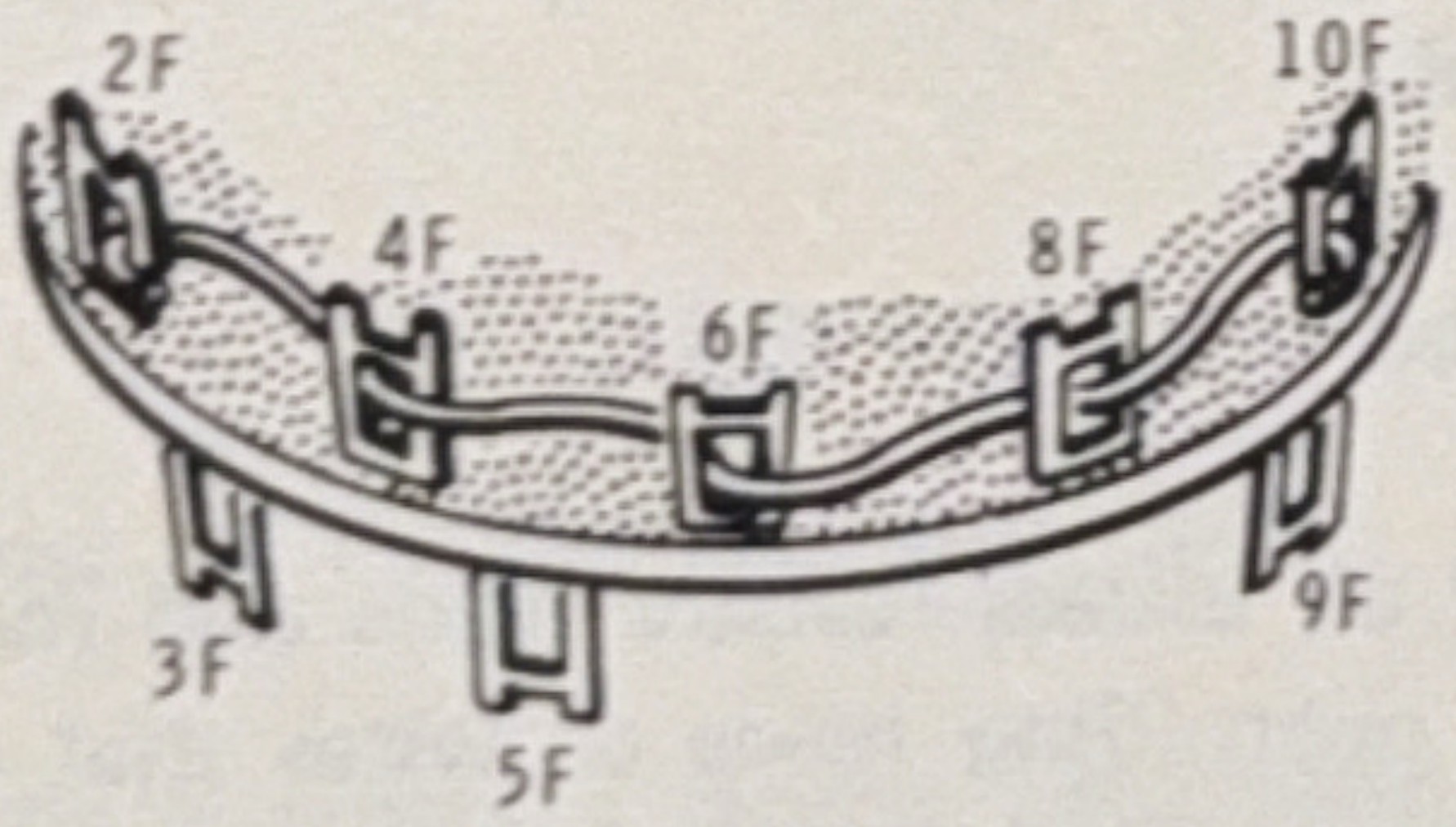
(✓) Cut off all excess resistor leads and make sure there are no protruding leads or wires that could cause a short circuit between switch lugs.

(✓) Position all wires as shown in the Pictorial.


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 .5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



PICTORIAL 4-5



Detail 4-5A

0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6
1/8 3/8 5/8 7/8
0 .5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Refer to Pictorial 4-5 for the following steps.

(✓) Loosen the control nut and turn the switch so it is positioned as shown in the Pictorial. Then tighten the control nut. NOTE: There is a lug at each switch position 1F through 10F.

Connect the wires to the lugs of switch SW2 as follows:

(✓) Refer to Detail 4-5A and connect a 2" small bare wire from lug 2F, through lugs 4F, 6F, and 8F and to lug 10F. Do not solder any of the connections at this time.

(✓) White wire coming from lug 14R to lug 3R (S-1).

(✓) White wire coming from lug 21F to lug 2F (S-2).

(✓) 1-1/4" black wire coming from lug 13F to lug 10F (NS).

Connect precision resistors to the switch lugs as follows:

(✓) 1000 Ω (1 k), .5% between lugs 5R (S-1) and 4F (NS).

(✓) 100 Ω, .5% between lugs 7R (S-1) and 6F (S-3).

(✓) 10.0 Ω, .5% between lugs 9R (S-1) and 8F (S-3).

(✓) 1 Ω, .1% between lugs 11R (S-1) and 10F (S-3).

(✓) Connect one lead of a 27 kΩ, 5% (red-violet-orange-gold) resistor to lug 1F (S-1). Wrap the other lead around lug 4F as shown in the Pictorial (S-4).

(✓) Cut off all excess resistor leads. Make sure there are no protruding leads that could cause a short circuit between switch lugs.

(✓) Prepare a 1-3/4" small red wire.

(✓) Connect this 1-3/4" red wire from lug 3F (NS) to lug 9F (S-1).

(✓) Prepare a 7" small red wire and connect one end to lug 3F on switch SW2 (S-2).

(✓) Route this red wire under switch SW1 as shown in the Pictorial and connect the other end to hole X on the circuit board (S-1).

(✓) Prepare a 6" small yellow wire and connect one end to lug 5F on switch SW2 (S-1).

(✓) Route the other end of the yellow wire under switch SW1 and connect it to hole Y on the circuit board (S-1).

Connect the wires coming from switch SW2 to the circuit board as follows:

(✓) 2-3/4" white coming from lug 12F to hole E (S-1).

(✓) 2-3/4" red coming from lug 14F to hole G (S-1).

(✓) 3" yellow coming from lug 22F to hole H (S-1).

(✓) 2-3/4" blue coming from lug 20F to hole J (S-1).

(✓) 2-3/4" green coming from lug 18F to hole K (S-1).

(✓) 2-3/4" brown coming from lug 16F to hole N (S-1).

(✓) 2-1/4" black coming from lug 13F to hole L (S-1).

(✓) Prepare a 2-1/2" small black wire. Then connect one end to hole M on the circuit board (S-1). The other end will be connected later.

(✓) Connect the 2-3/4" yellow wire coming from lug 14R on switch SW1 to lug 1R on switch SW2 (S-1).

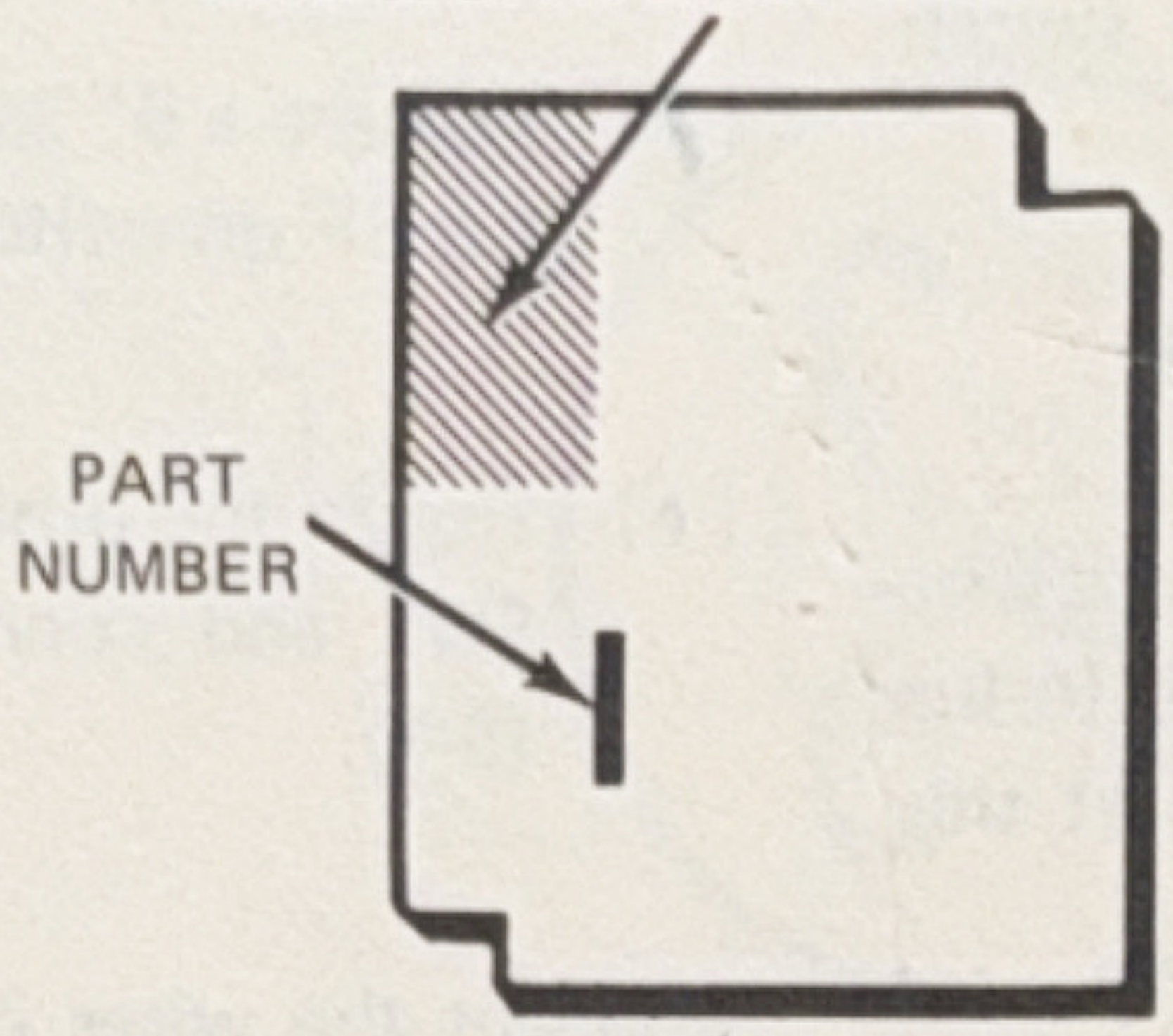
(✓) Connect the 4-3/4" blue wire coming from lug 12R on switch SW2 to lug 5R on switch SW1 (S-2).

(✓) Connect the 4-3/4" white wire coming from lug 16R on switch SW2 to lug 5F on switch SW1 (S-1).

(✓) Prepare a 5" small red wire and connect one end to lug 7F on switch SW1 (S-1). The other end will be connected later.

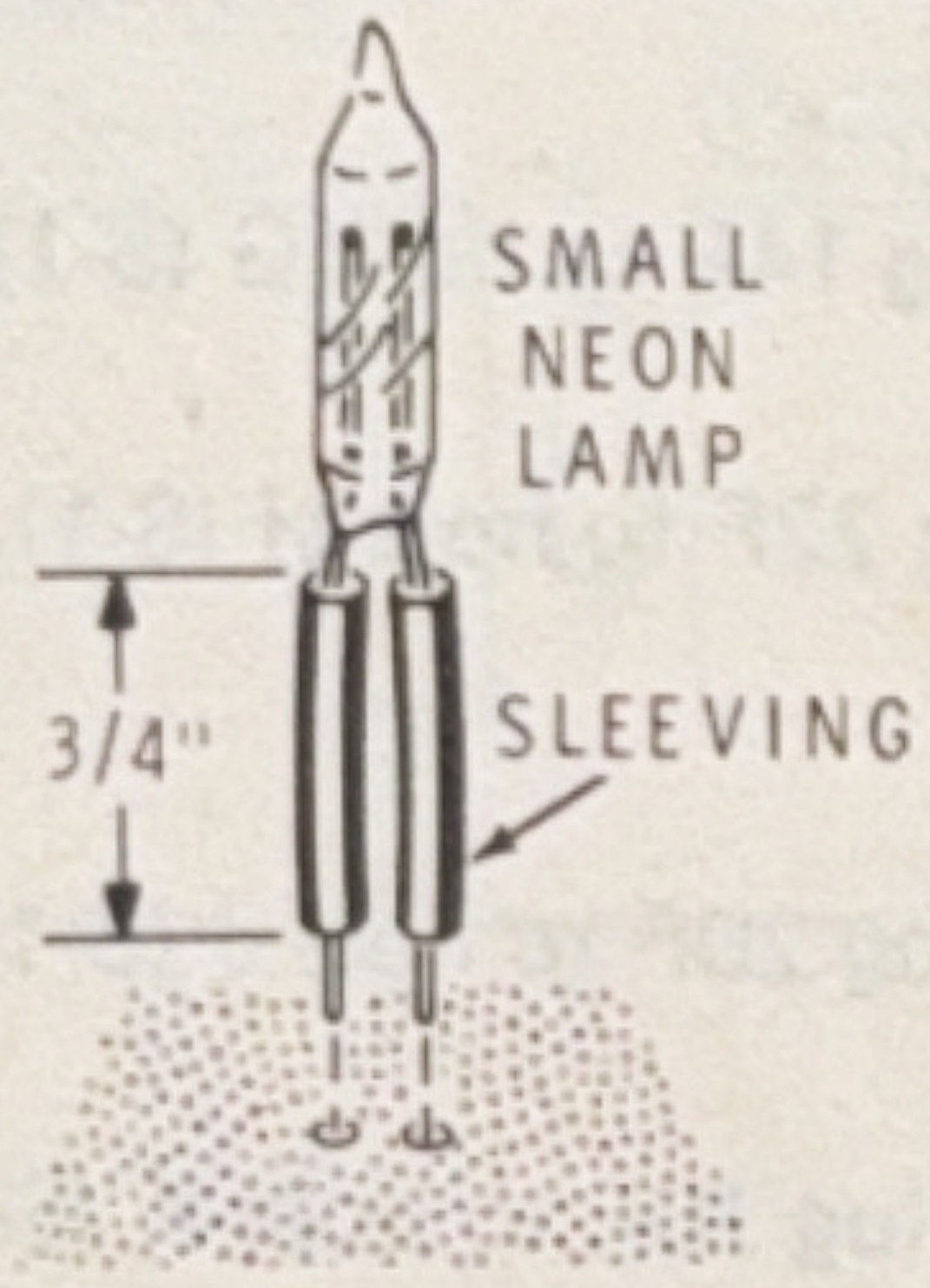
DISPLAY INSTALLATION

The steps performed in this Pictorial are in this area of the circuit board.



IDENTIFICATION DRAWING

START

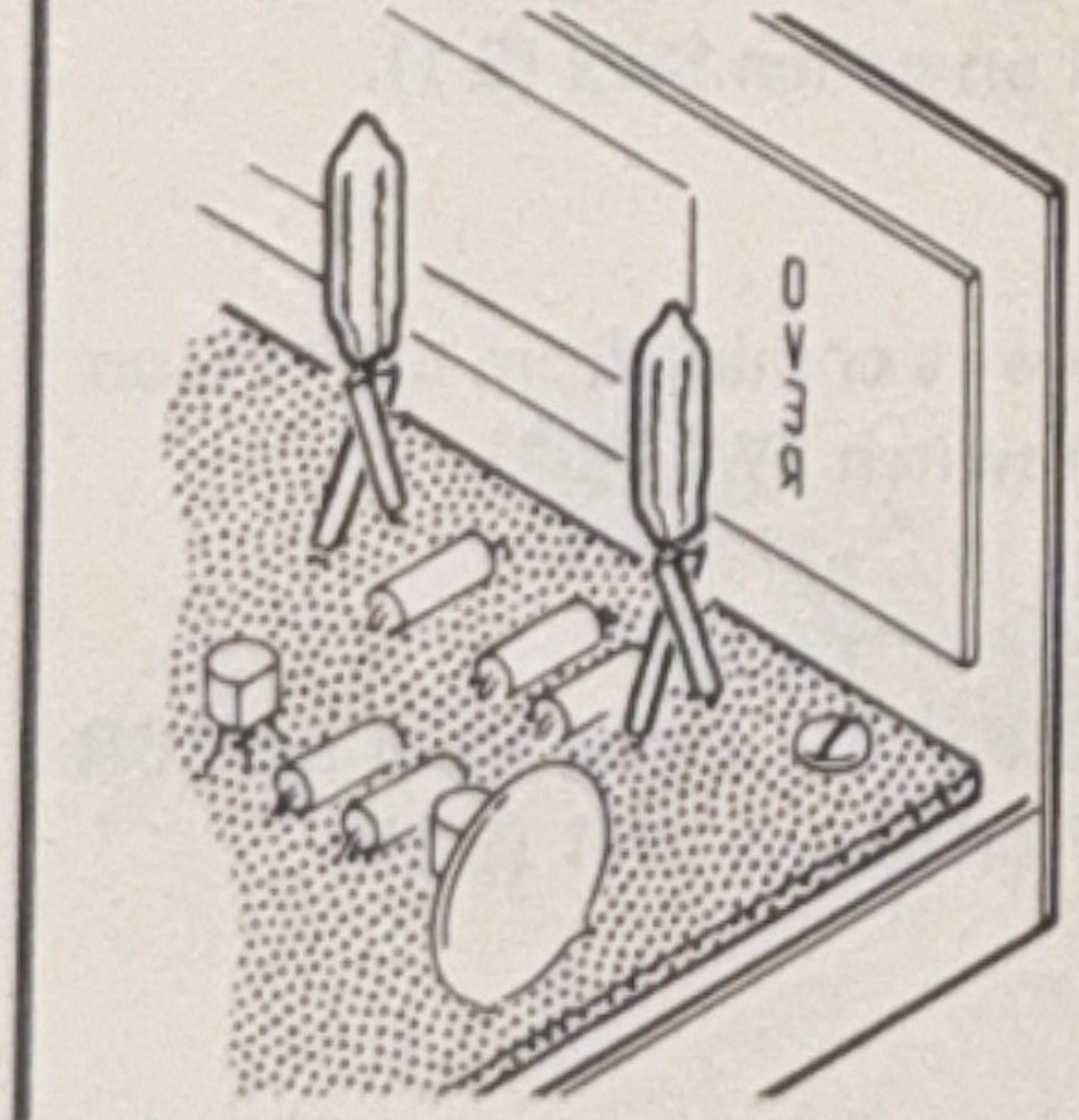


(✓) Place a 3/4" length of sleeving over each lead of both neon lamps.

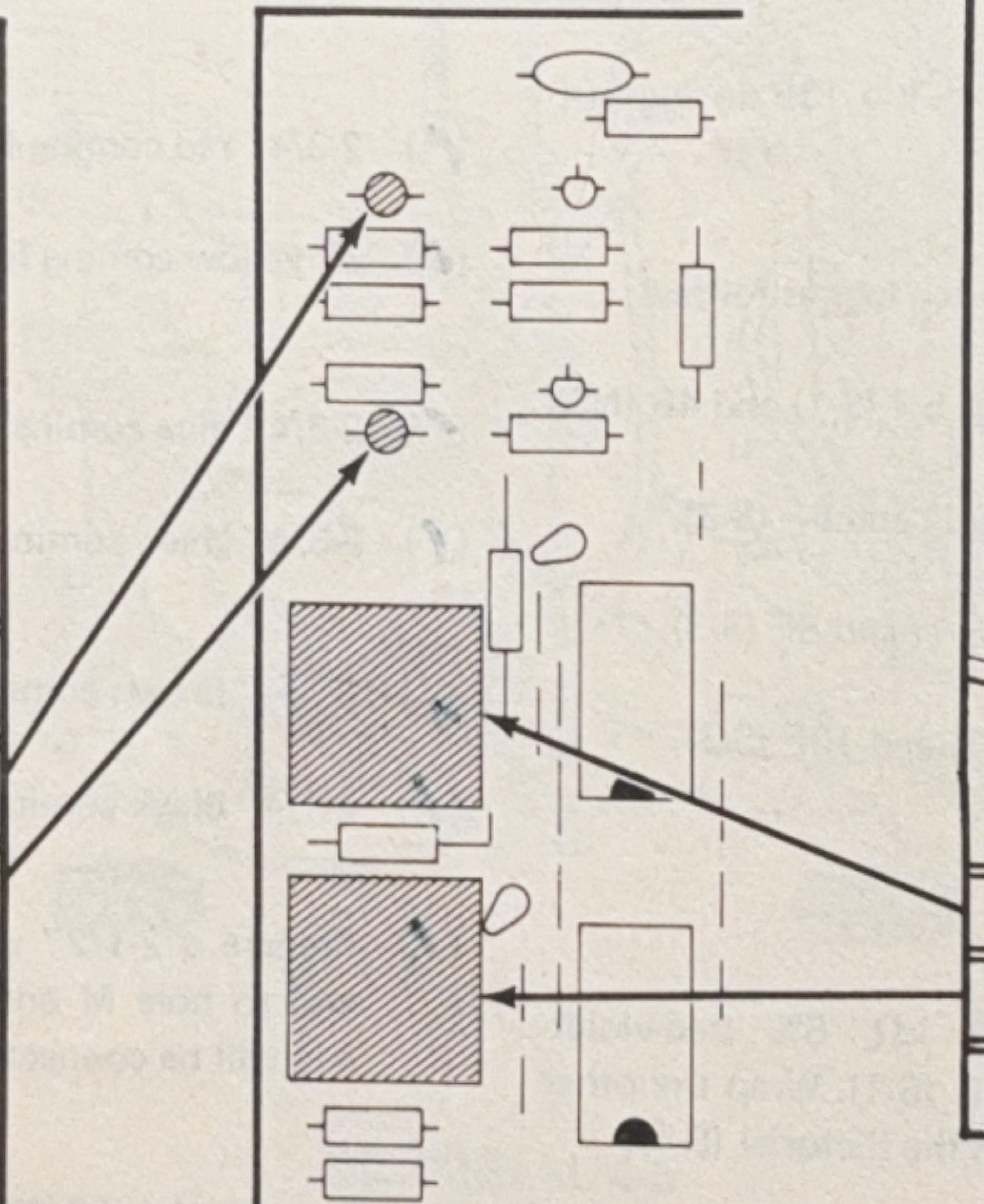
(✓) Install a neon lamp at DS201.

(✓) Install the other neon lamp at DS202.

(✓) Rotate both neon lamps 180 degrees as shown. The rear lead illuminates the element to which it is connected. This element should be toward the front.

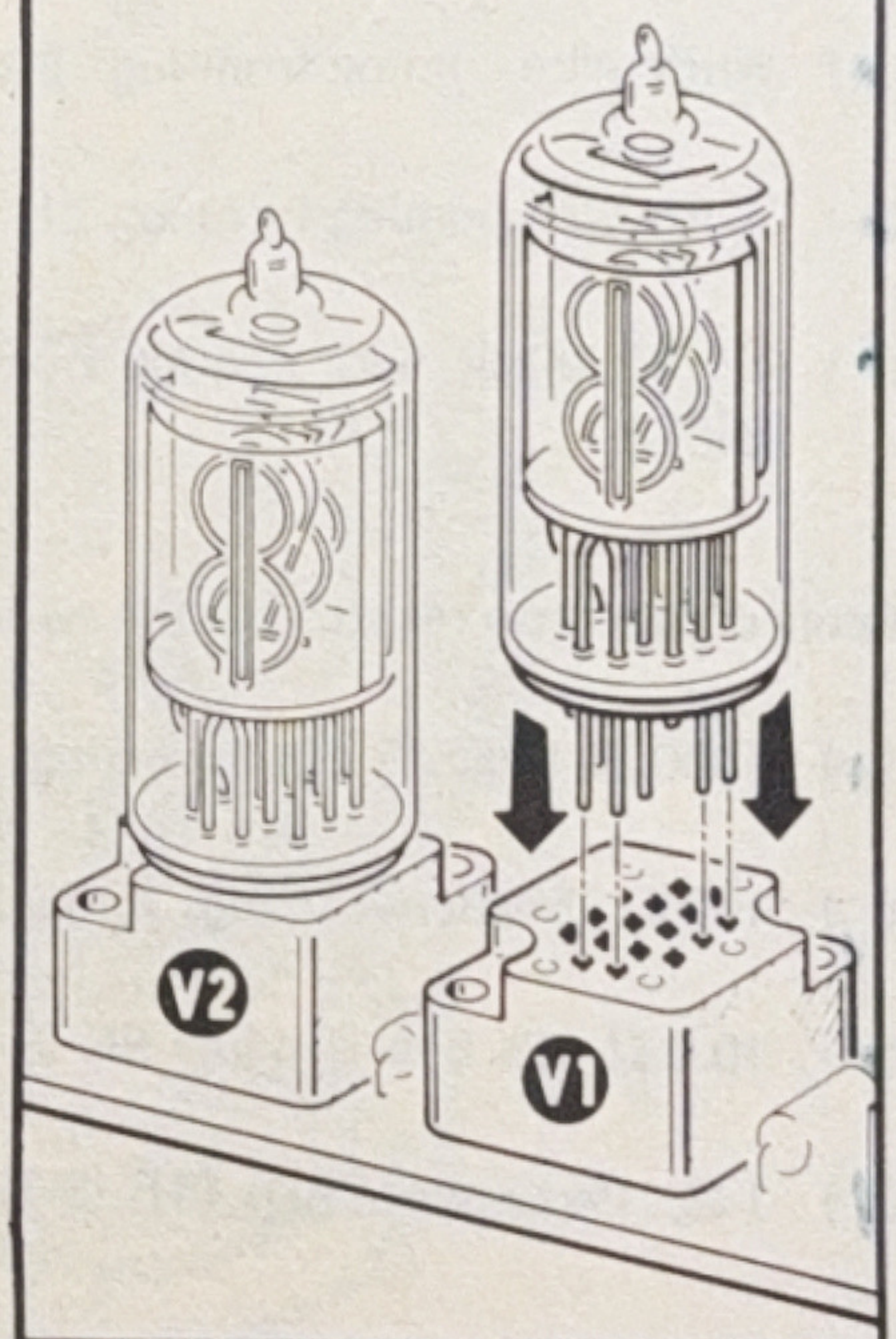


(✓) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

NOTE: When you install the display tubes in the following steps, make sure all of the tube pins are straight. Then position the tubes so the display numbers face the outside edge of the circuit board and push the tubes gently down into the sockets.

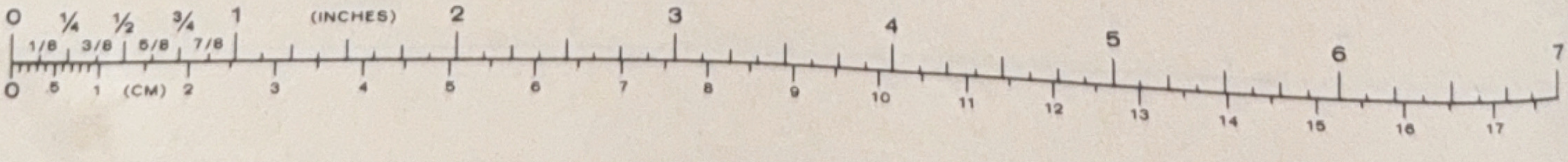


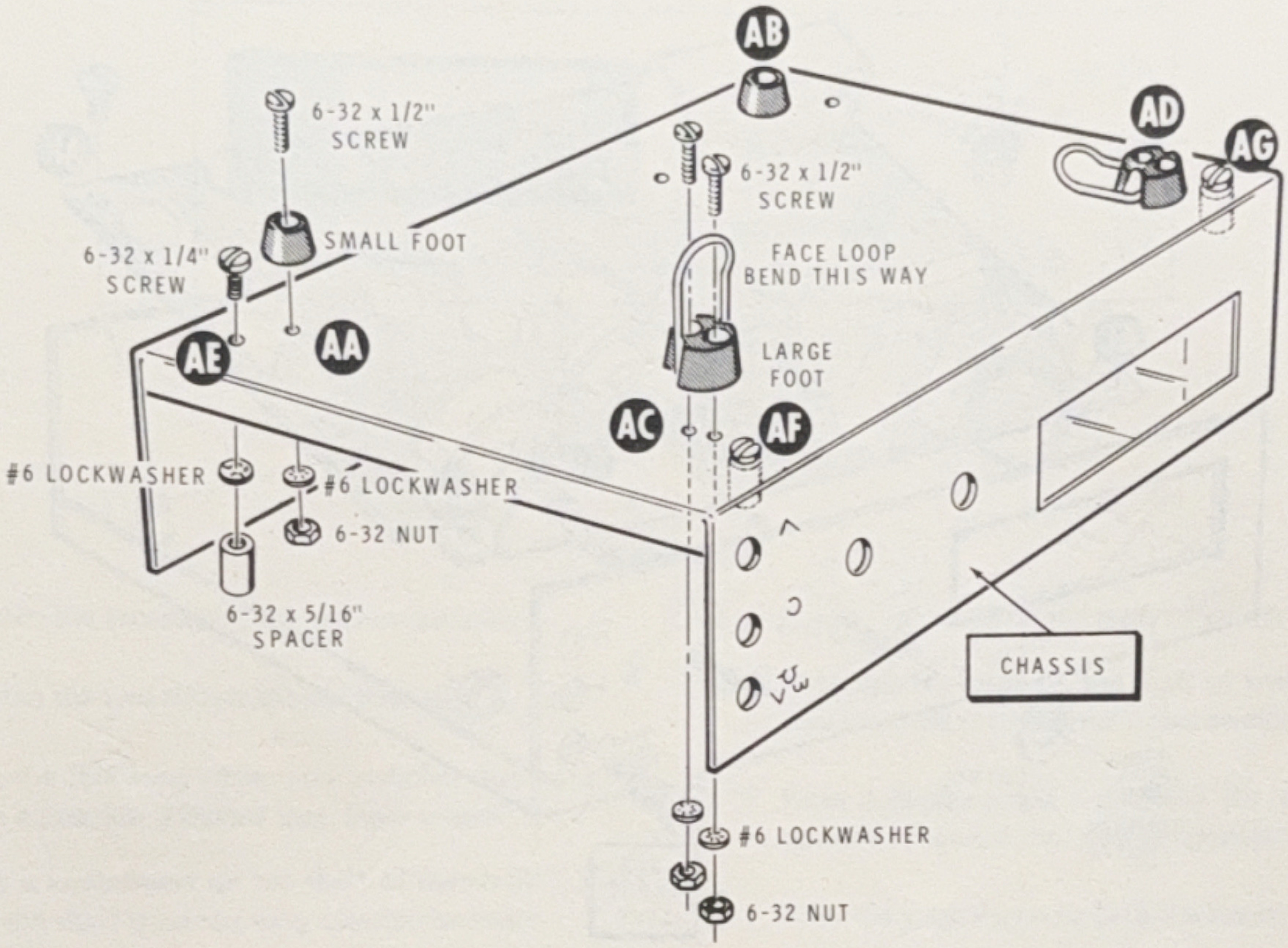
(✓) Display tube at V2.

(✓) Display tube at V1.

Set the circuit board aside temporarily.

PICTORIAL 5-1


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 .5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17



PICTORIAL 6-1

CHASSIS ASSEMBLY AND WIRING

Refer to Pictorial 6-1 for the following steps.

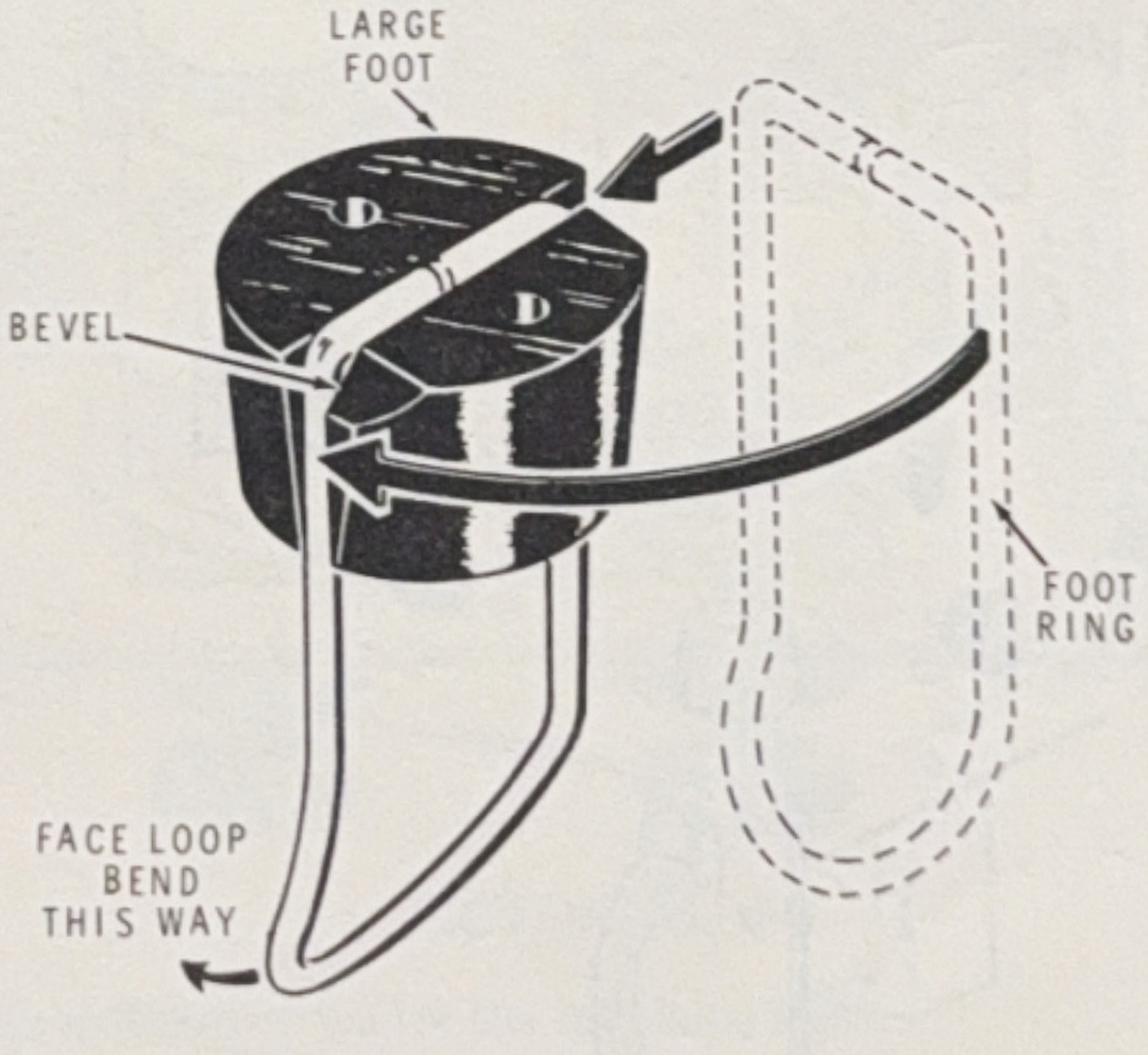
(✓) Position the chassis as shown in the Pictorial.

(✓) Mount 6-32 x 5/16" spacers at holes AE, AF, and AG with 6-32 x 1/4" screws and #6 lockwashers.

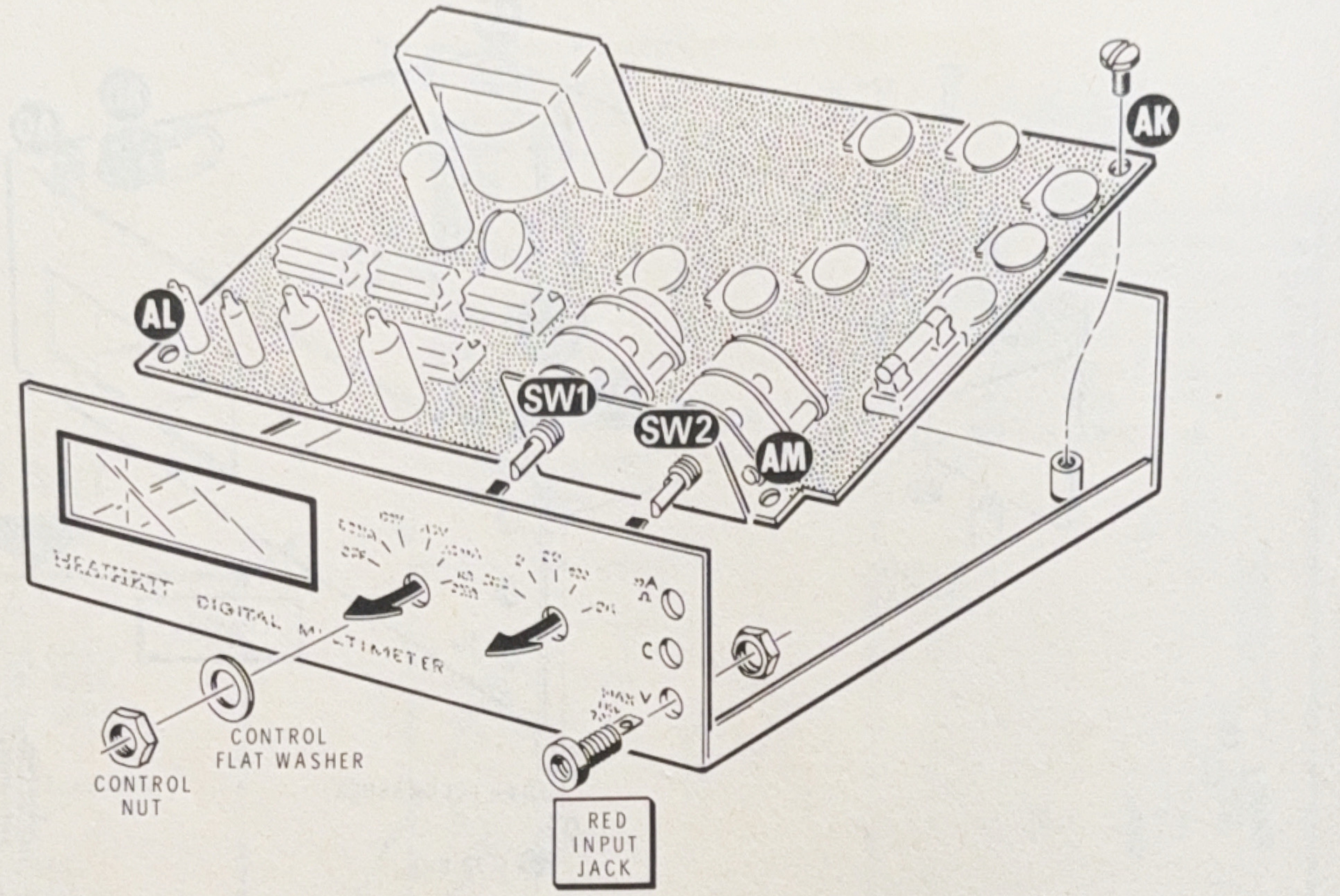
(✓) Mount small feet at holes AA and AB. Use two 6-32 x 1/2" screws, two #6 lockwashers and two 6-32 nuts.

(✓) Refer to Detail 6-1A and install a foot ring on each of the two large feet.

(✓) Mount large feet at holes AC and AD. Use four 6-32 x 1/2" screws, four #6 lockwashers and four 6-32 nuts. Make sure both feet are positioned as shown in the Pictorial with the beveled edge toward the rear of the chassis. Then lay the foot ring flat and make sure it remains straight while you tighten the screws.



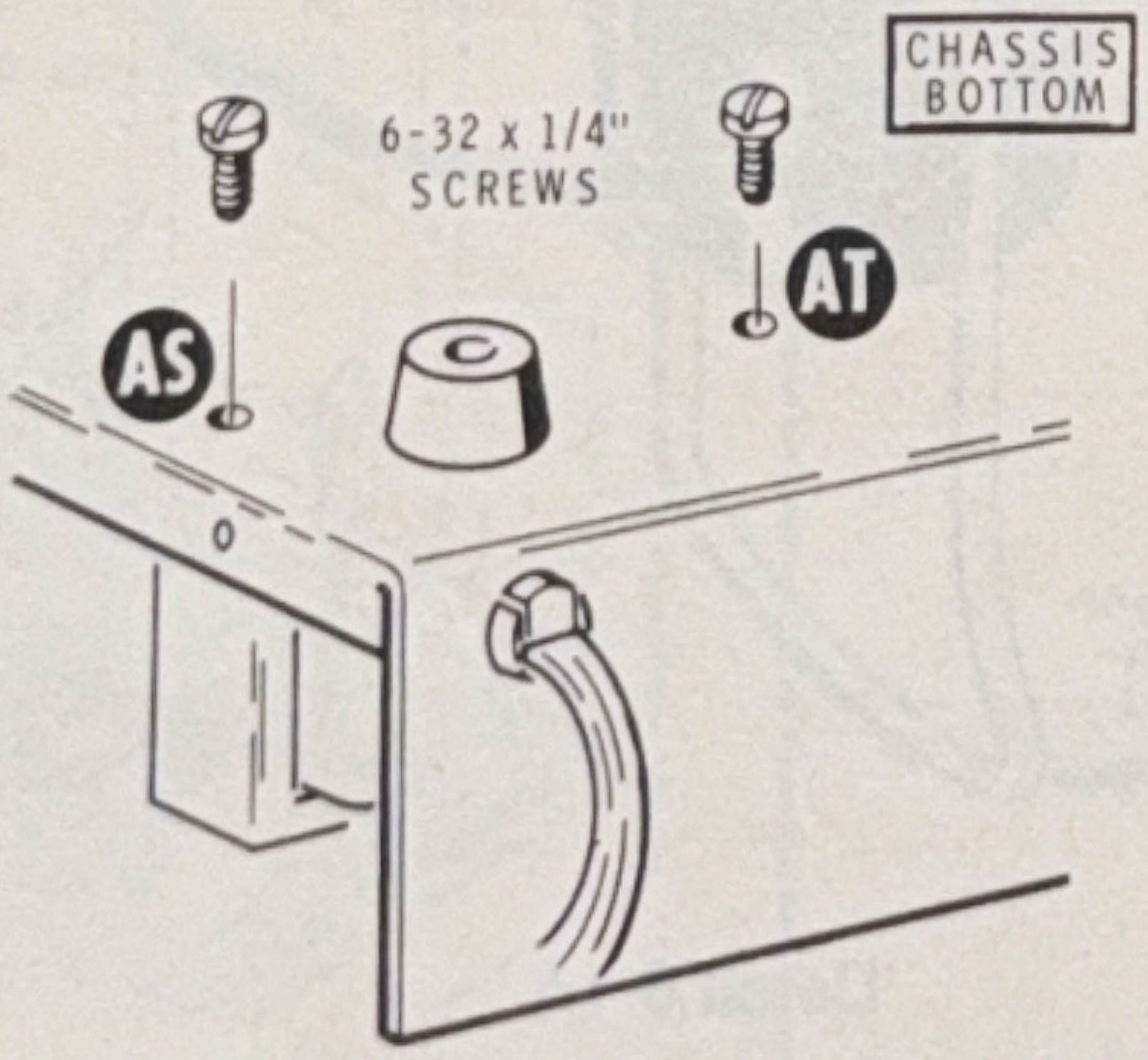
Detail 6-1A



PICTORIAL 6-2

Refer to Pictorial 6-2 for the following steps.

(✓) Remove the two control nuts from switches SW1 and SW2.



Detail 6-2A

(✓) Position the shafts of the switches through the holes at the front of the chassis and set the circuit board down inside the chassis.

(✓) Mount the two switches to the chassis with control flat washers and control nuts. Tighten the control nuts only finger tight.

(✓) Temporarily loosen the two switch bracket mounting screws.

(✓) Fasten the circuit board to the chassis with 6-32 x 1/4" screws at holes AK, AL, and AM.

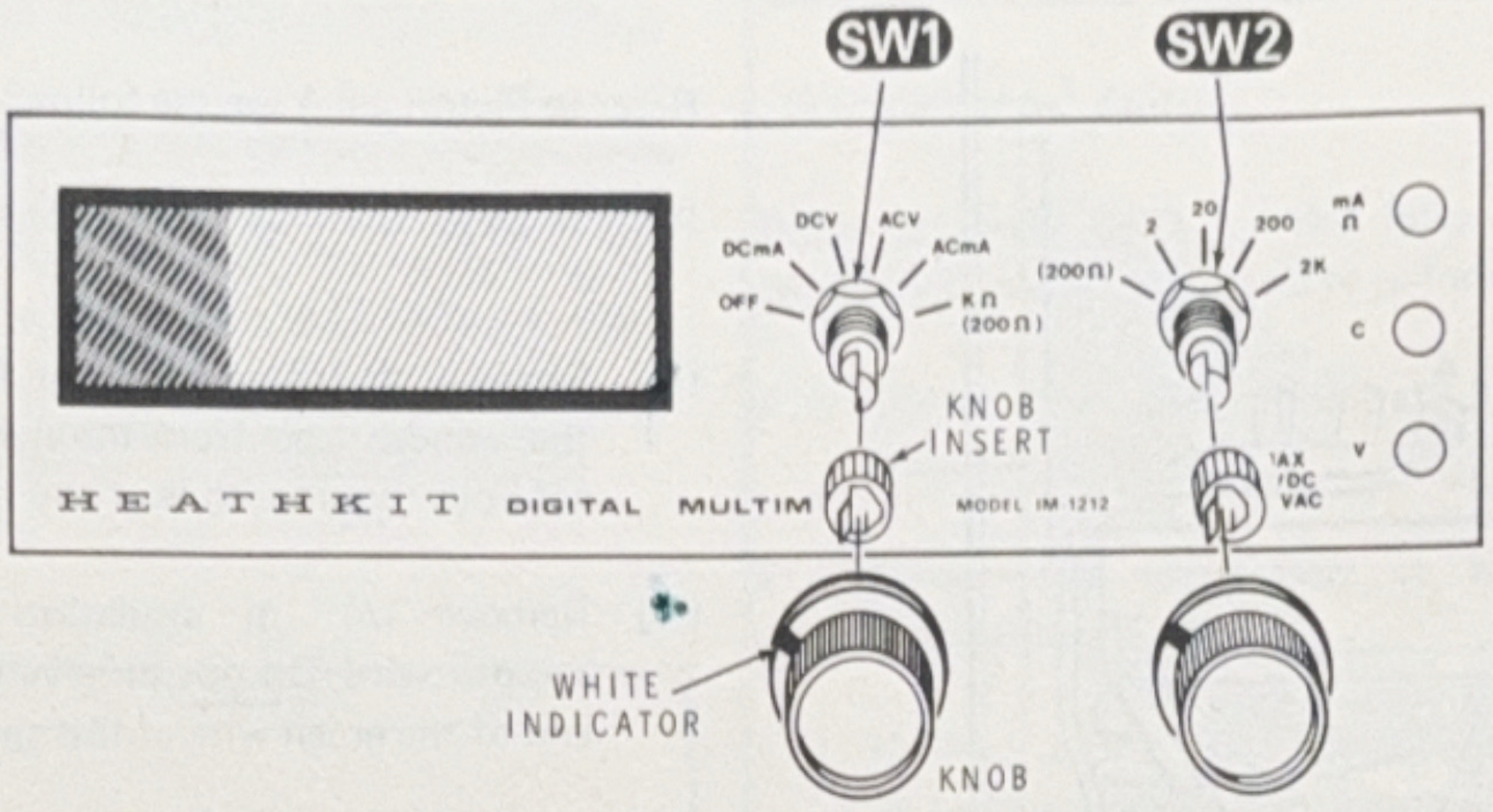
(✓) Refer to Detail 6-2A and secure the transformer spacers to the chassis bottom at AS and AT with 6-32 x 1/4" screws as shown.

NOTE: In the following steps, mount the input jacks on the chassis with their attached nuts.

( ) Red input jack at the hole marked "V."

(✓) Black input jack at the hole marked "C."

(✓) White input jack at the hole marked "mA Ω."



Detail 6-2B

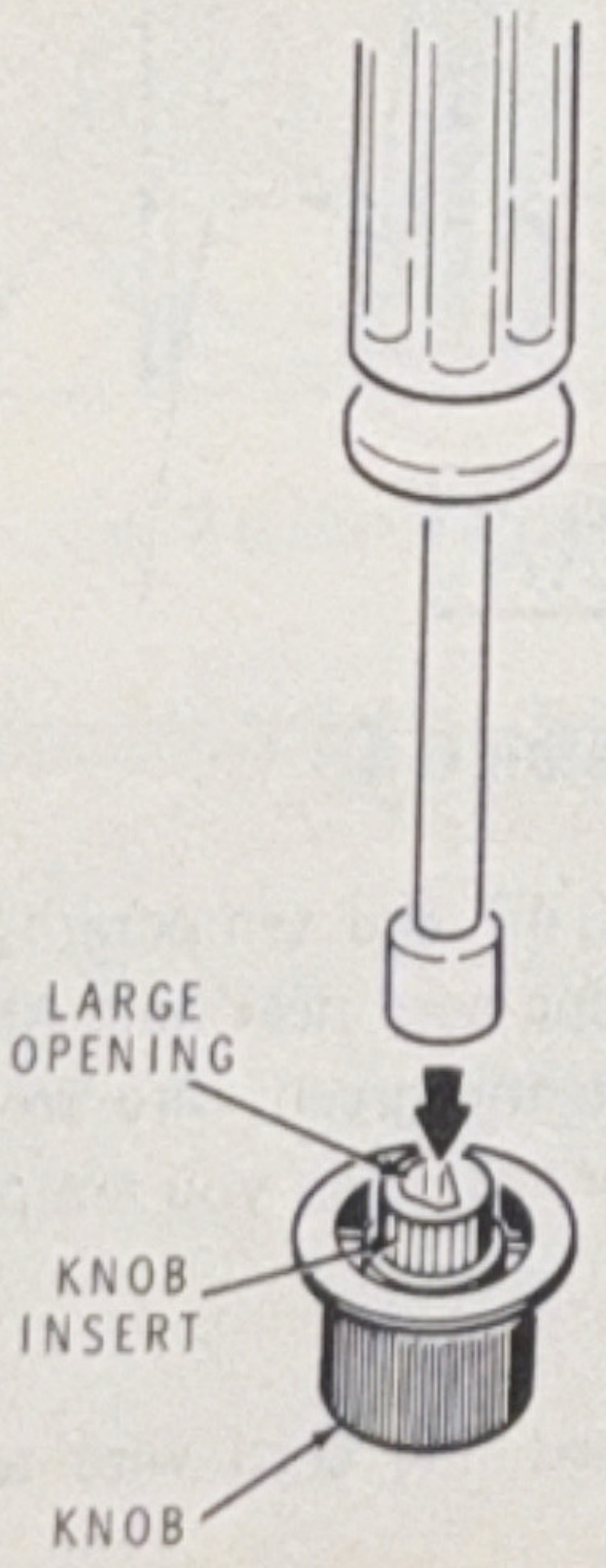
( ) Tighten the two switch control nuts securely.

( ) Tighten the two switch bracket mounting screws.

NOTE: In the following steps, your switches may have flat portions in a position different than those shown.

( ) Place a knob insert on the shaft of switch SW1. Make sure the shaft is turned fully counterclockwise.

( ) Refer to Detail 6-2B and push a knob on the knob insert with the white indicator positioned to the "OFF" position. Press the knob part way onto the insert.



Detail 6-2C

( ) Carefully remove the knob and insert together. Then press the insert fully into the knob with a tool as shown in Detail 6-2C.

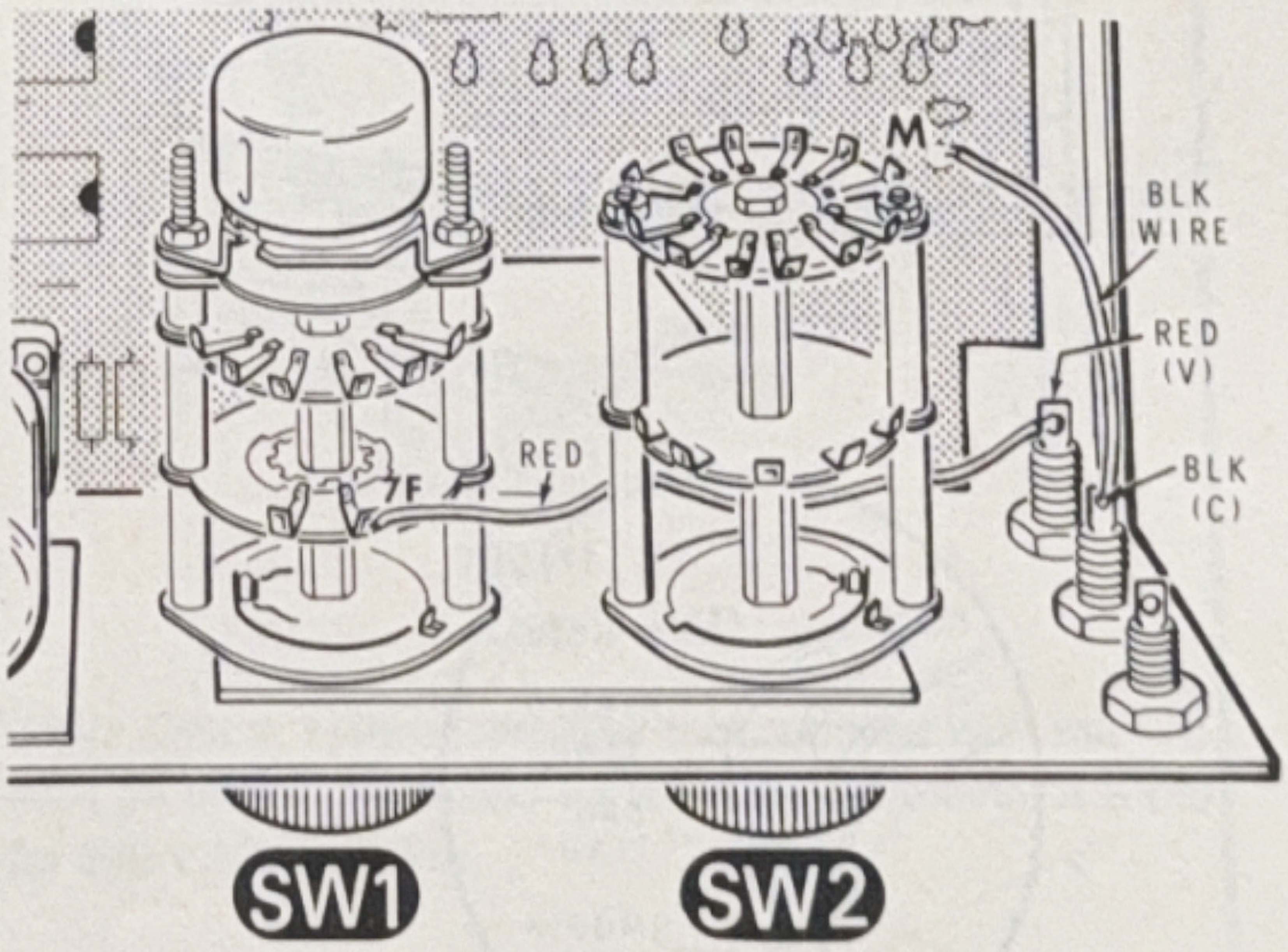
( ) Replace the knob on the shaft of switch SW1.

( ) Place a knob insert on the shaft of switch SW2. Make sure the shaft is turned fully counterclockwise.

( ) Place a knob on the insert with the white indicator positioned toward the "200 Ω" position.

( ) Press the knob part way onto the insert.

( ) As before, remove the knob and insert together. Then press the insert fully into the knob and replace the knob on the switch shaft.

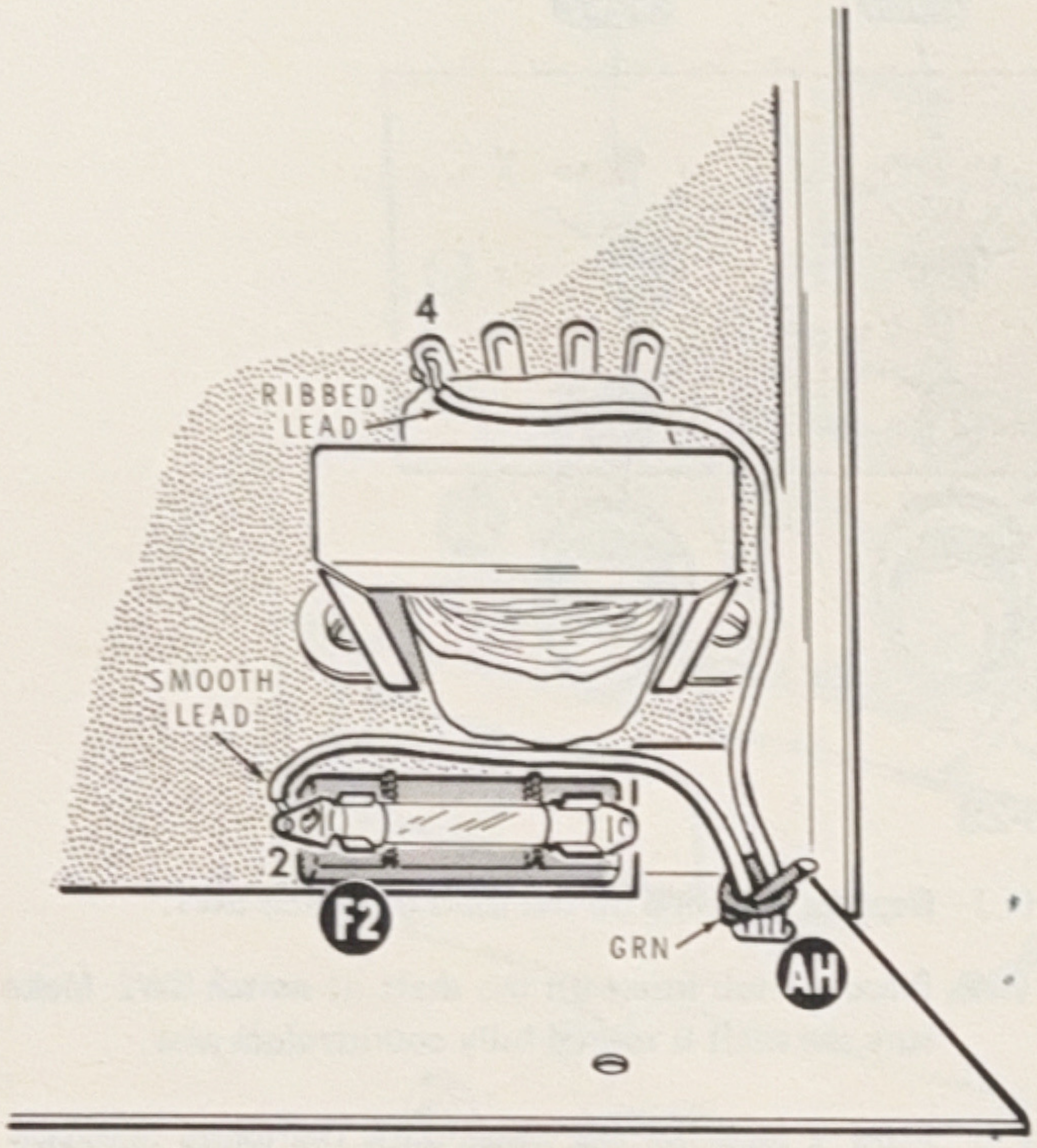


PICTORIAL 6-3

Refer to Pictorial 6-3 for the following steps.

( ) Connect the black wire coming from circuit board hole M to the black (C) test jack on the front panel (S-1).

( ) Connect the red wire coming from switch SW1 lug 7F to the red (V) test jack on the front panel (S-1).



PICTORIAL 6-4

Refer to Pictorial 6-4 for the following steps.

Refer to Detail 6-4A and prepare the line cord as follows:

(✓) Separate the three leads for a length of 4". Identify the smooth lead from the inset drawing; then cut 1" off both the smooth lead and the green lead.

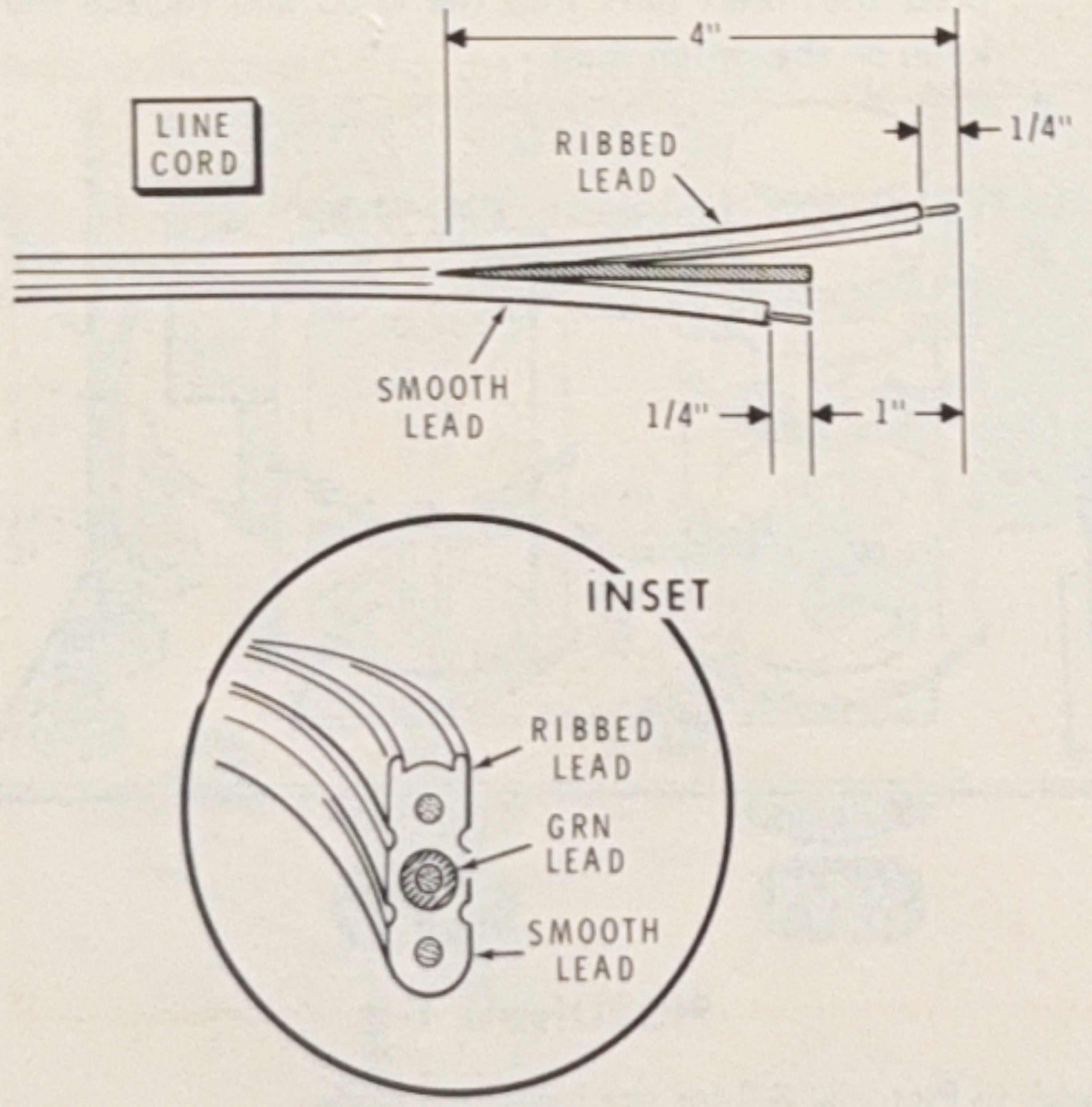
(✓) Remove 1/4" of insulation from the end of the smooth wire. Do not remove any insulation from the end of the green wire at this time.

(✓) Twist the small wire strands together on the ribbed wire and on the smooth wire. Then melt solder on the ends to hold the small strands together.

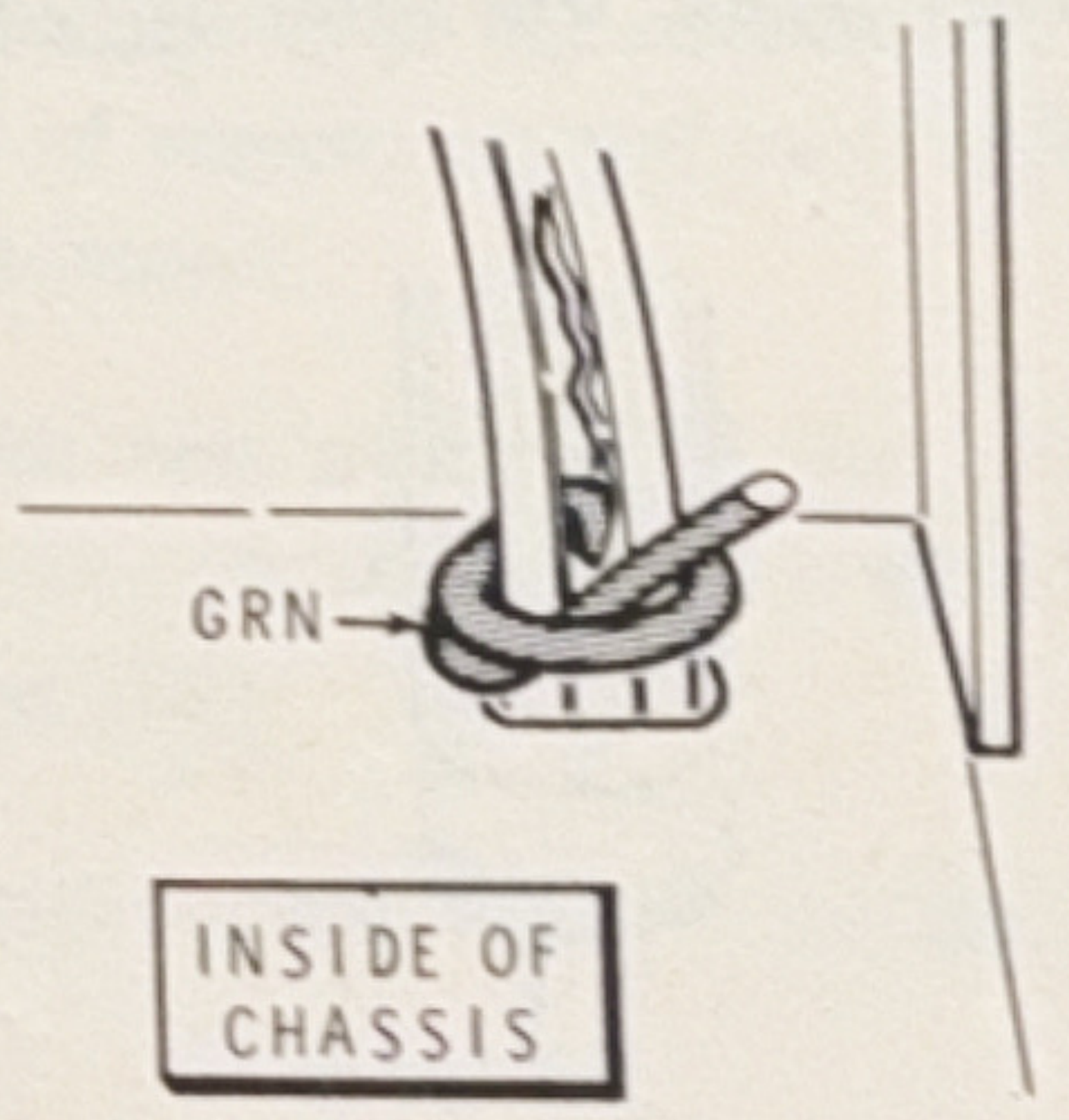
(✓) Insert the line-cord wires through hole AH at the rear of the chassis as shown in the Pictorial.

NOTE: Be sure to make the connections in the following steps mechanically secure by wrapping each wire end tightly around the indicated lug.

(✓) Connect the smooth wire to lug 2 of fuseholder F2 (S-1).



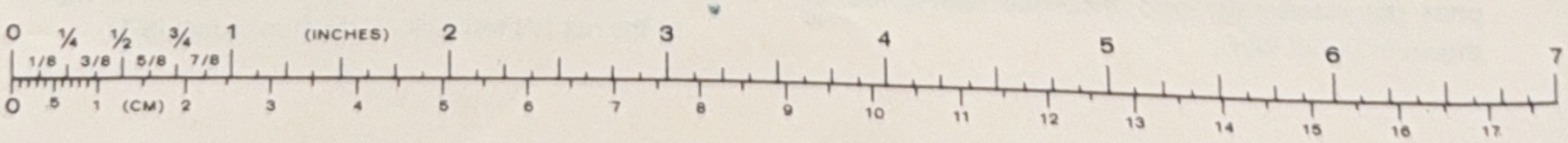
Detail 6-4A



Detail 6-4B

(✓) Refer to Detail 6-4B and temporarily tie the green wire around the line cord near hole AH in the chassis. This will prevent the green wire from accidentally causing a short circuit when you are performing tests and adjustment.

(✓) Connect the ribbed line cord wire to lug 4 of the transformer (NS).



ALTERNATE POWER TRANSFORMER WIRING

NOTE: The following steps give two different sets of wiring instructions. One set of instructions is for 120 VAC line voltage and the other is for 240 VAC line voltage. In the United States, 120 VAC is most often used, while in many other countries 240 VAC is more common. Use only the instructions that agree with the line voltage in your area.

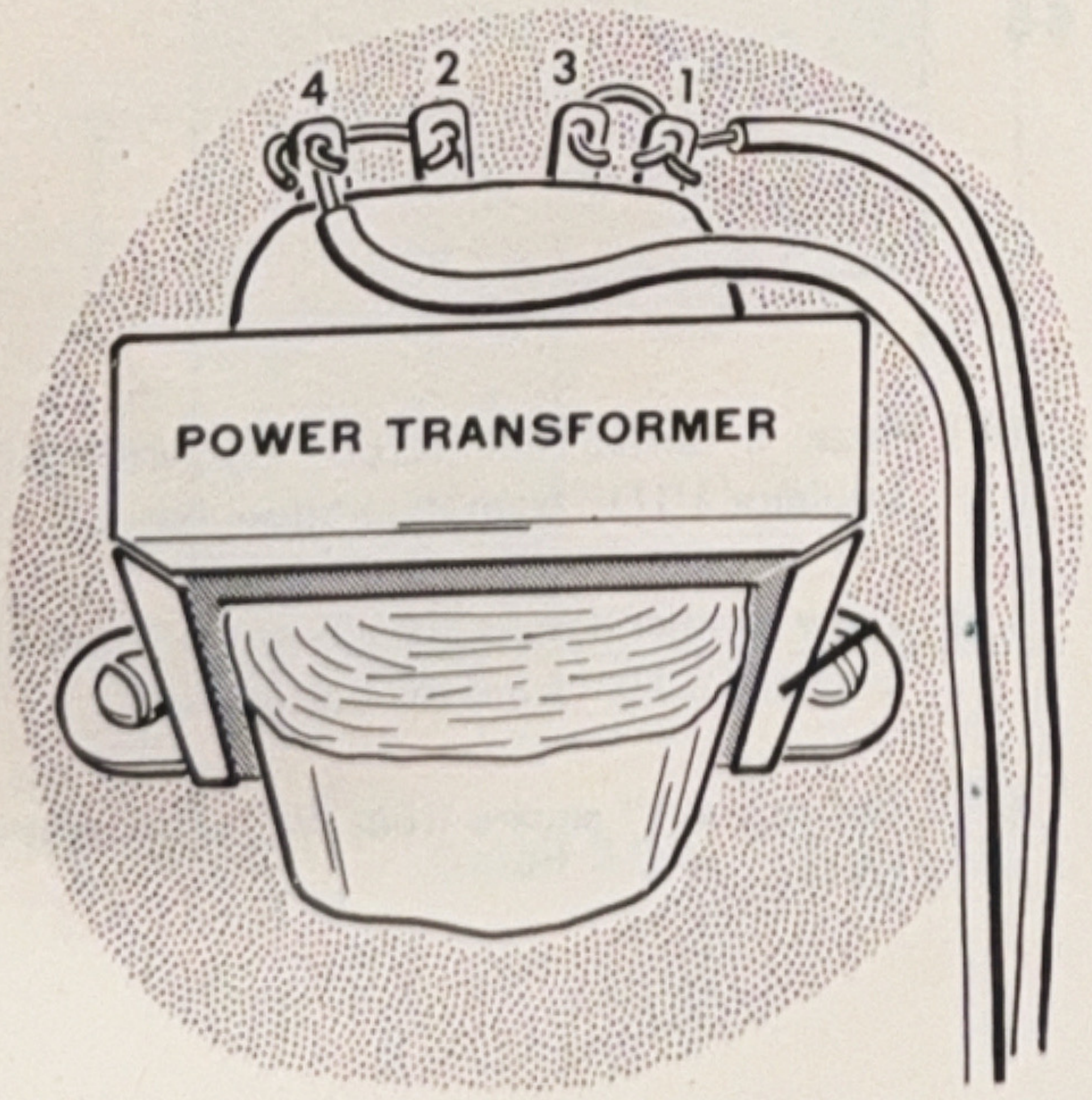
For 120 VAC Only

Refer to Detail 6-4C for the following steps. Make each connection mechanically secure before soldering.

(●) Connect a 3/4" bare wire between lugs 1 (S-2) and 3 (S-1) of the power transformer.

(●) Connect a 3/4" bare wire between lugs 2 (S-1) and 4 (S-2) of the power transformer.

120 VOLT WIRING



Detail 6-4C

For 240 VAC Only

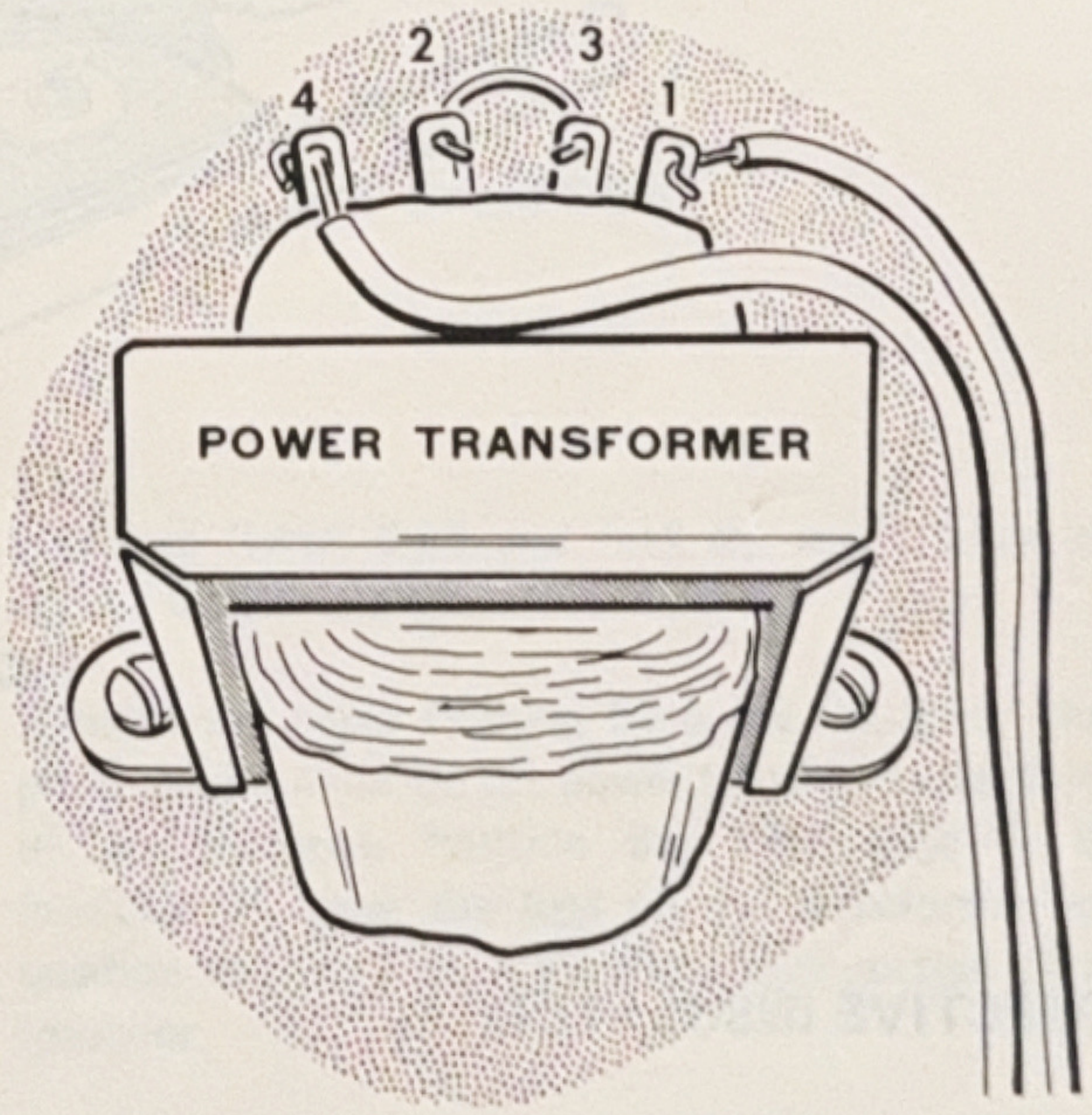
Refer to Detail 6-4D for the following steps. Make each connection mechanically secure before soldering.

( ) Solder the connection at lug 4 of the power transformer (S-1).

( ) Solder the connection at lug 1 of the power transformer (S-1).

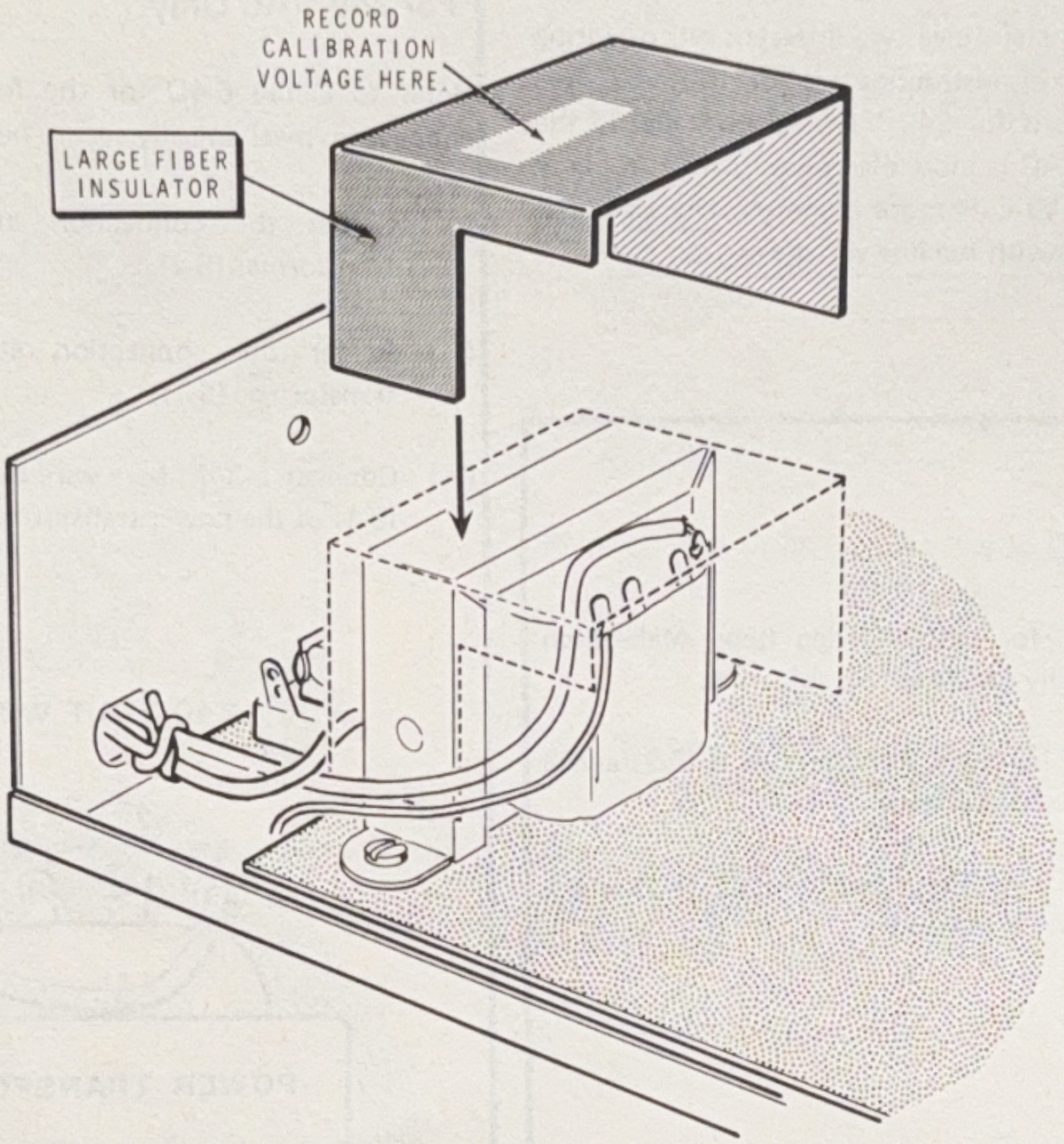
( ) Connect a 3/4" bare wire between lugs 2 (S-1) and 3 (S-1) of the power transformer.

240 VOLT WIRING



Detail 6-4D

CAUTION: A 1/16-ampere fuse (not supplied with this kit) must be used in fuseholder F2 when the Multimeter is wired for 240 VAC operation.



PICTORIAL 6-5

PROTECTIVE INSULATOR

Refer to Pictorial 6-5 for the following steps.

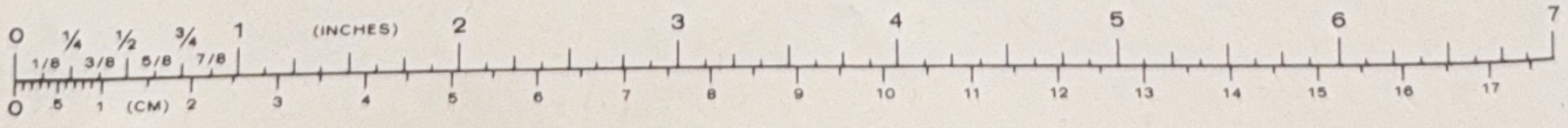
Refer to Detail 6-5A and prepare the large fiber insulator as follows:

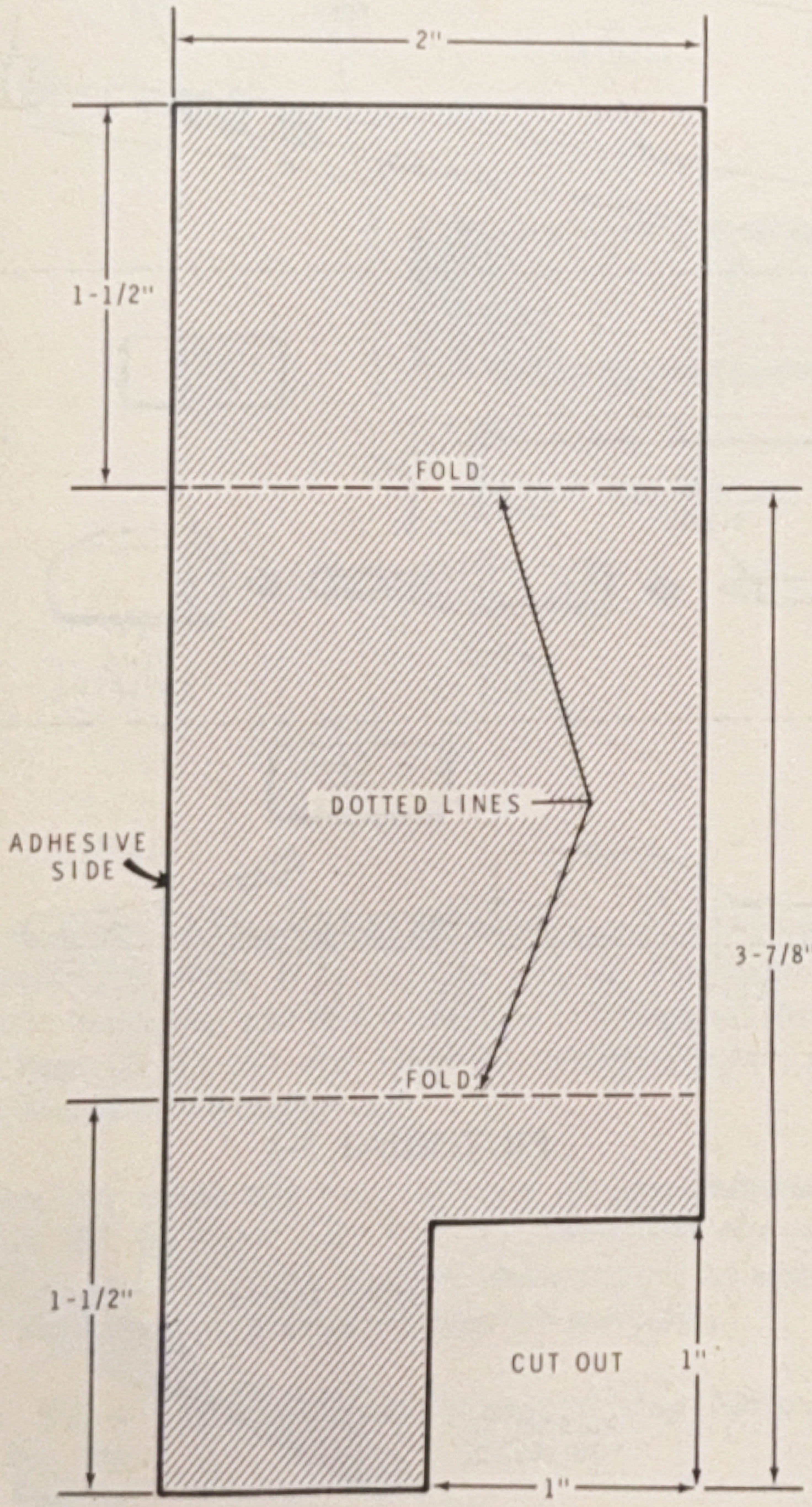
1. (✓) Cut the insulator to a width of 2". Then lay the insulator on your work surface with the adhesive side down.

2. (✓) Draw a dotted line across the width of the insulator 1-1/2" from the bottom edge.

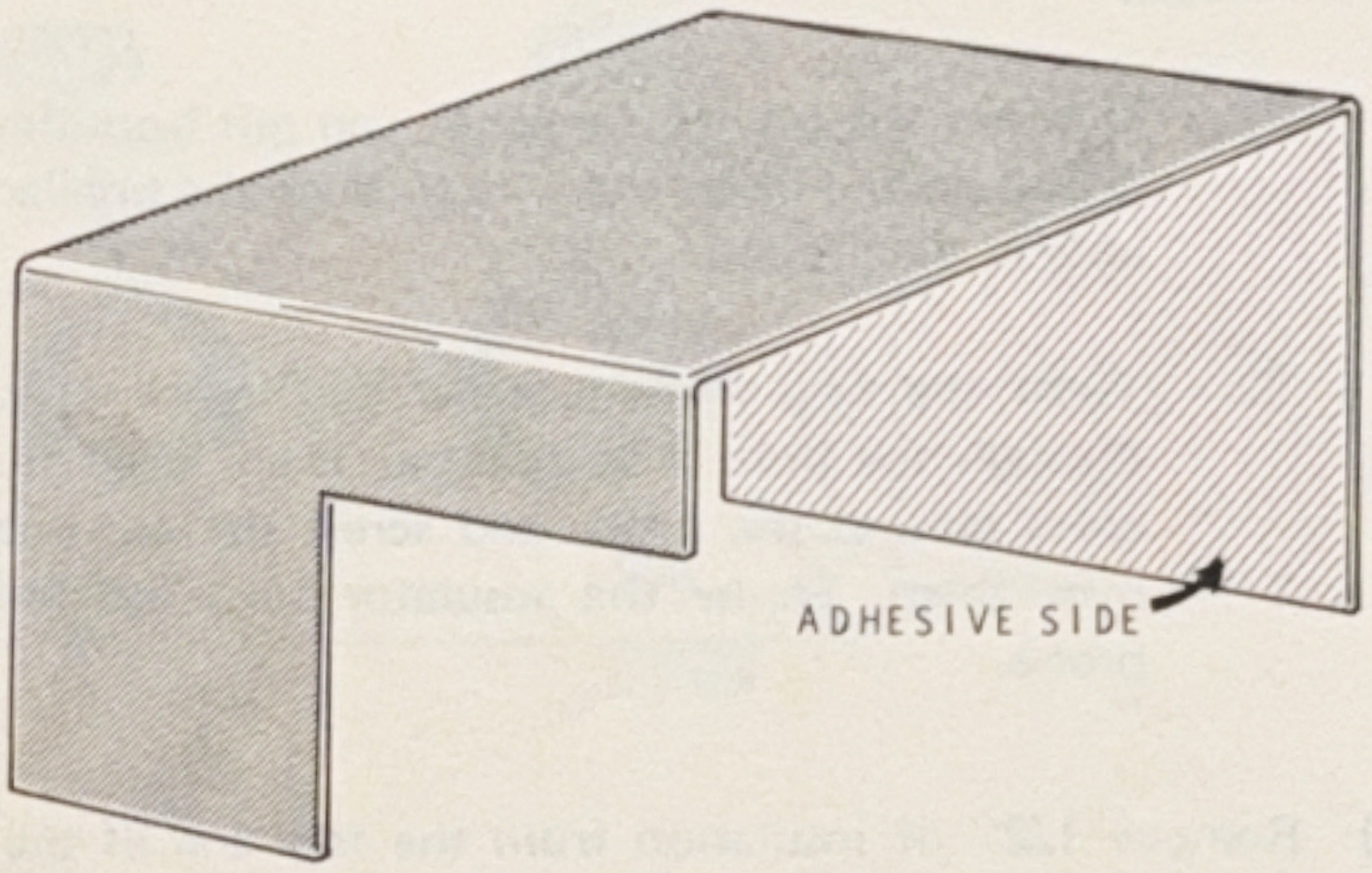
3. (✓) Draw another dotted line across the width of the insulator 3-7/8" from the bottom edge.

4. (✓) Cut out a 1" square from the lower right-hand corner.





Detail 6-5A



Detail 6-5B

( ) Refer to Detail 6-5B and fold the insulator on the dotted lines as shown.

( ) Remove the paper backing from the insulator. Then place the insulator on the power transformer as shown in the Pictorial. Position the front edge of the insulator to cover the lugs on the transformer and position the wires through the cutout portion of the insulator.

( ) Refer to the first step on Page 10 of the Manual where you recorded the value of the calibration voltage. Then, record the calibration voltage on top of the insulator as shown in the Pictorial.

TEST LEAD ASSEMBLY

Refer to Pictorial 7-1 and prepare the meter test leads.

(✓) Remove 1/2" of insulation from one end of the red test lead.

(✓) Install a test probe on this end of the red test lead as follows:

1. Unscrew the insulator and the cap nut from the probe tip and insert the wire through the smaller hole in the insulator.

2. Twist the fine wires together and insert them through the hole in the probe. Then form the wires around the probe and screw the cap nut over them. Screw the insulator back on the probe.

(✓) Remove 1/2" of insulation from the free end of the red test lead.

(✓) Insert this end of the red test lead into an input plug as shown. Then bend the wire flat against the plug body.

(✓) Place the input plug on a small phillips screwdriver (or similar tool) and push a red plug insulator onto the plug and wire until the plug is fully seated.

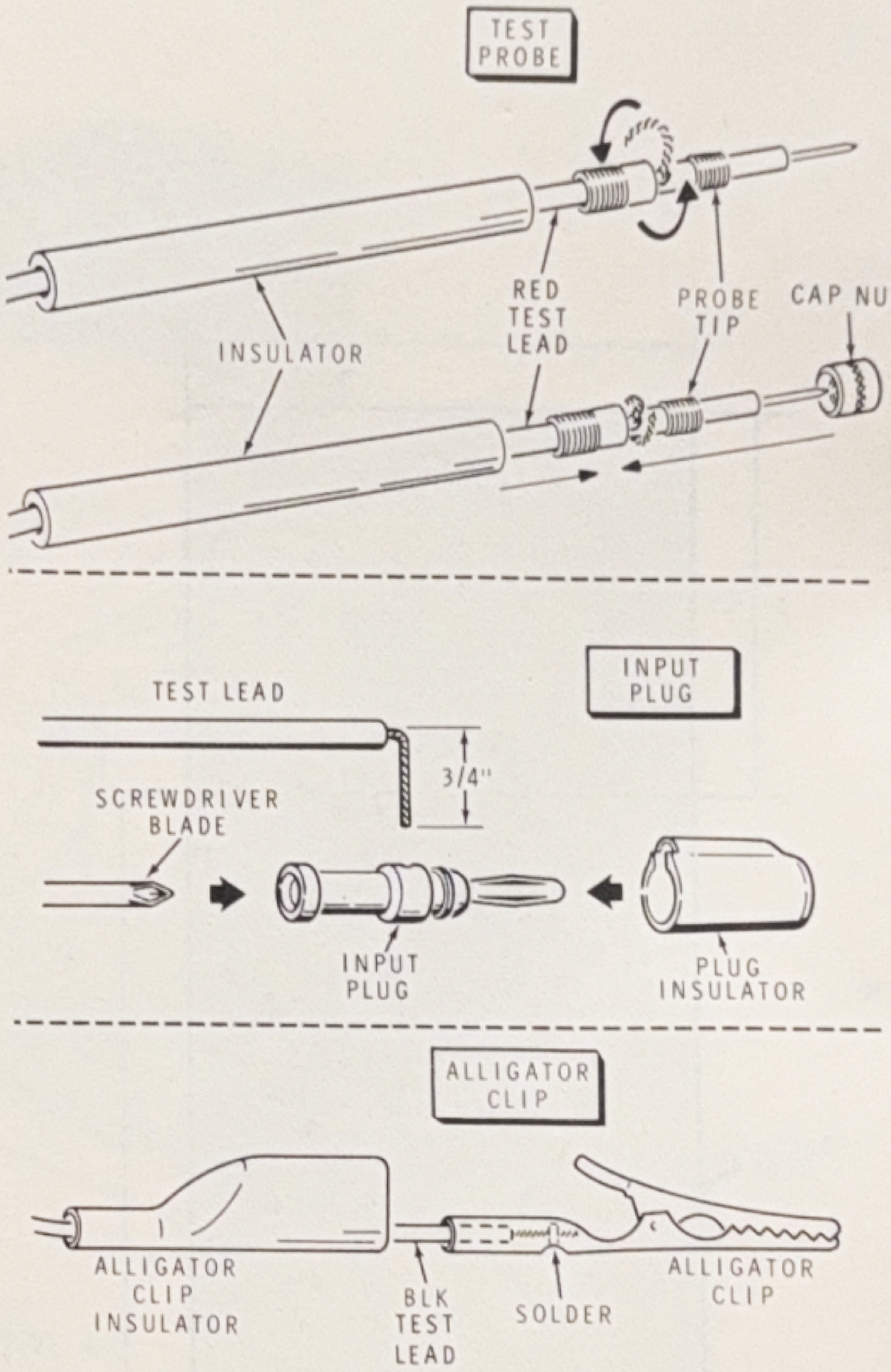
( ) Remove 1/2" insulation from one end of the black test lead.

( ) In the same manner, install an input plug and black plug insulator on this end of the black test lead.

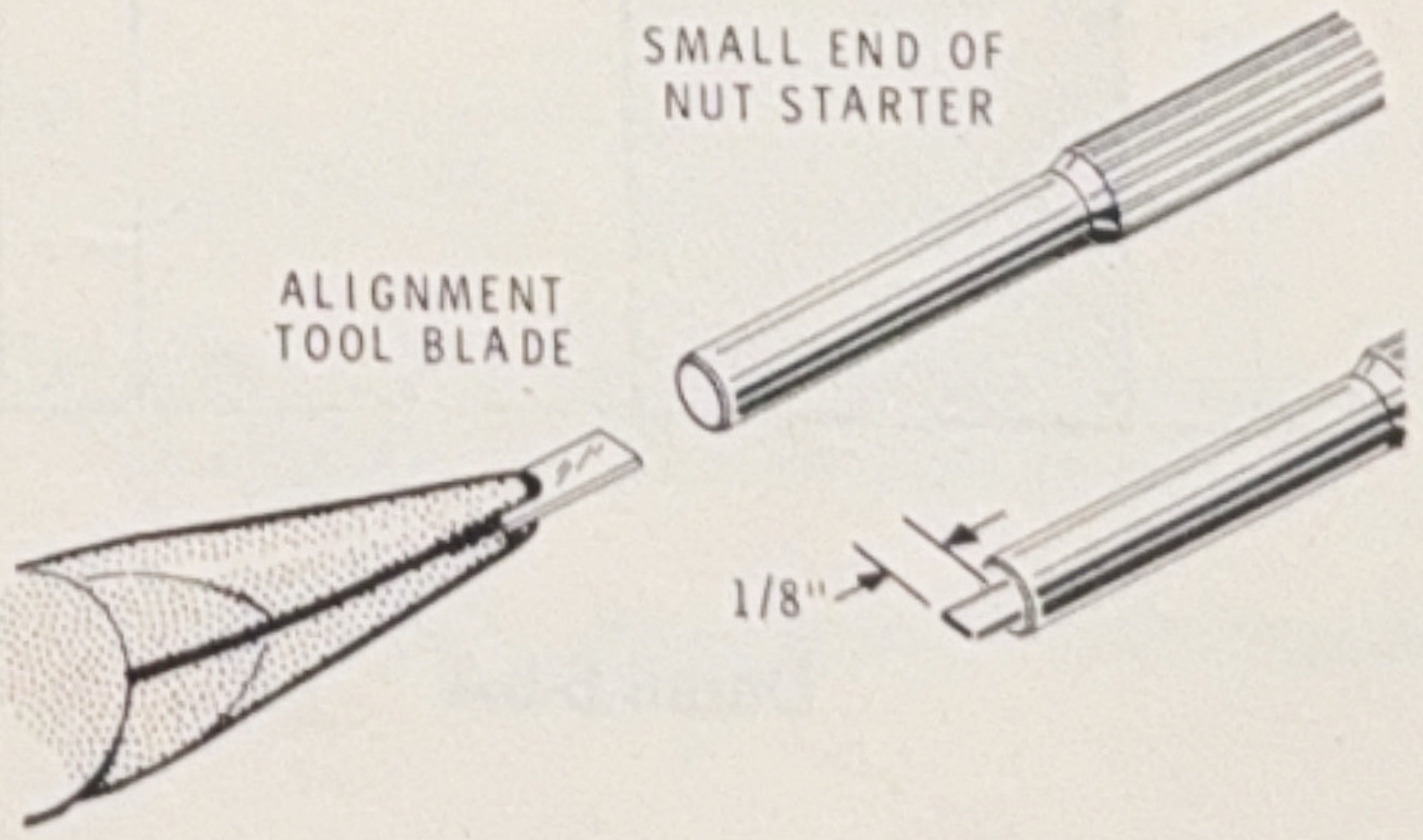
( ) Remove 1/2" insulation from the "free" end of the black test lead.

( ) Insert the end of the black test lead through the smaller end of the alligator clip insulator. Twist the fine wires together and insert them into the alligator clip (S-1). Slip the alligator clip insulator down over the alligator clip after the clip has cooled.

( ) Refer to Pictorial 7-2 and push the alignment tool blade into the small end of the nut starter as shown.



PICTORIAL 7-1



PICTORIAL 7-2

This completes the "Step-by-Step Assembly" section of your Digital Multimeter. The cabinet will be installed later.

Proceed with the "Tests and Calibration" section of the Manual.

NOTE: Save any parts remaining; they will be used later.

TESTS AND CALIBRATION

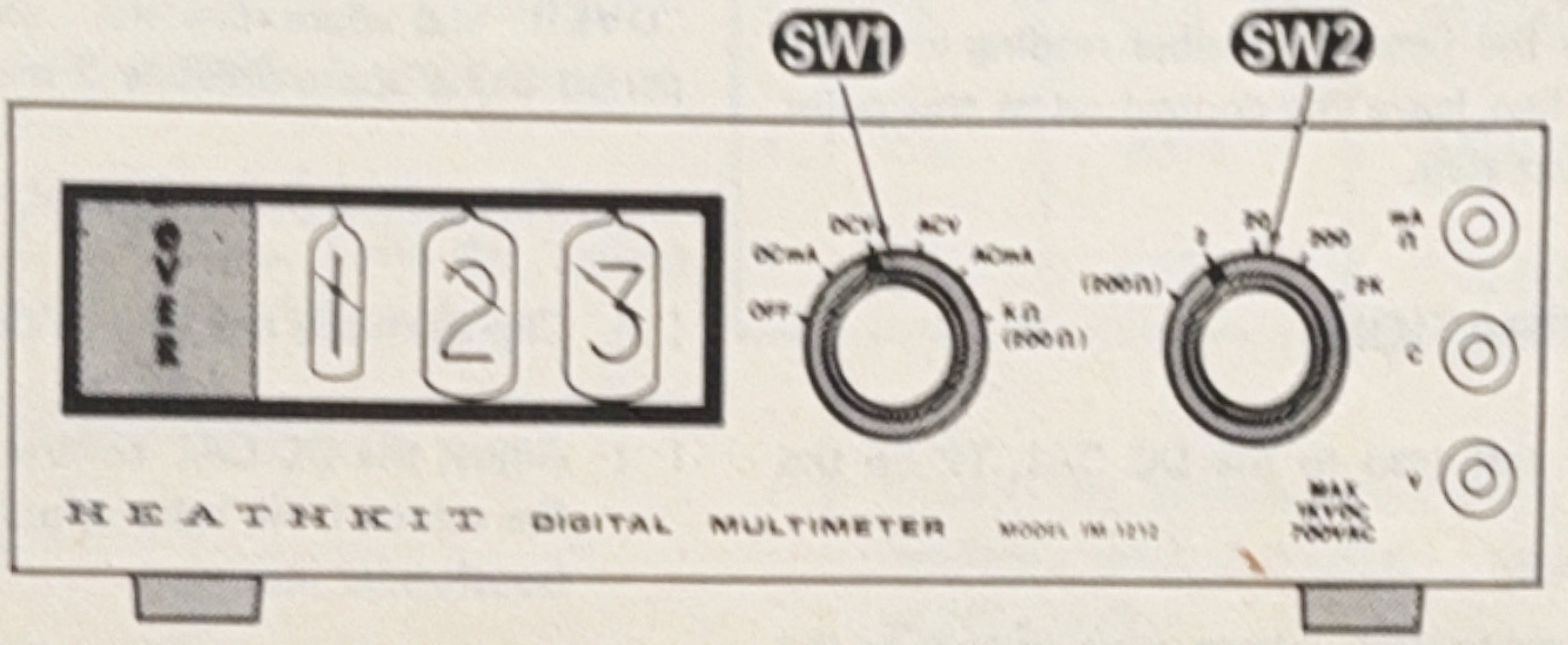


Figure 2-1

In this section of the Manual you will test and calibrate your Digital Multimeter. If at any time you do not obtain the results indicated, refer to the "In Case of Difficulty" section on Page 50. Locate and repair any problem before you continue with the calibration.

Figure 2-1 shows the front switches of your Multimeter. Figure 2-2 (fold-out from Page 41) shows the remaining controls and test points. Carefully study Figures 2-1 and 2-2 and identify the function of each switch and control.

(✓) Set all ten circuit board controls to their centers of rotation.

( ) Turn the DC CAL control 1/4 turn counterclockwise.

( ) Set the front panel switches to the following positions.

SW1 OFF
SW2 2.

WARNING: When the line cord is connected to an AC outlet, hazardous voltages will be present at several places. These are shown by the boxed-in area in Figure 2-2.

(•) Plug the line cord into an AC outlet.

(•) Turn the switch SW1 to the DCV position and allow the unit to stabilize for at least 30 minutes. NOTE: The two right-hand digits (displaying any number) and the decimal point to the left of the left digit should all be lit. No other lamp should be lit.

ZERO ADJUST

(•) Plug the black test lead into the V (red) front panel jack.

(•) Connect the alligator clip on the black test lead to the rear socket lug of the C (black) jack. This will short the voltage input jack temporarily.

(•) Turn the ZERO ADJ control until the readout is .01. Then slowly turn the control until the readout just changes .00. The display should change back and forth between .01 and .00.

(•) Remove the black test lead clip from the C (black) jack.

OSCILLATOR ADJUST

Refer to Figure 2-2 (fold-out from Page 41) for the following steps.

(•) Turn switch SW1 to the KΩ position and adjust the OSC ADJ control for a readout of "OVER .85," +15 digits.

NOTE: If you are unable to obtain a reading of exactly "OVER .85," obtain the nearest possible reading with the OSC ADJ control. Then leave the control set at this point and proceed to the next step.

DC VOLTS CALIBRATION

(•) Clip the black test lead to the DC CAL TP on the circuit board.

NOTE: Refer to the calibration voltage value written on the transformer insulator to perform the following step. Observe that the calibration voltage number has four digits, whereas the Multimeter can display only three digits. Convert the number to three digits by dropping the fourth digit if it is 4 or less, or by increasing the third digit by one if the fourth digit is 5 or more. For example:

1.943 = 1.94
1.946 = 1.95

If the value on the envelope is 2 or higher, the Multimeter OVER lamp will be lit in the following step, but the 2 will not be displayed:

2.112 = OVER .11.

(•) Turn switch SW1 to the DCV position.

(✓) Adjust the DC CAL control until the readout matches the value of the calibration voltage.

(•) Remove the test lead from the DC CAL test point.

Repeat the preceding steps in the following manner:

( ) Turn switch SW1 to the KΩ position.

( ) Adjust the Oscillator Adjust control for a readout of "OVER .85."

NOTE: This time, the reading must fall within 15 digits (that is, no less than "OVER .70," or no more than "OVER 1.00)." If you are unable to calibrate within these limits, refer to the "In Case of Difficulty" section of the Manual. If your Multimeter is operating from a 60 Hz power line during calibration, the infinity display will be "OVER" and approximately ".85." In the unusual case when a 50 Hz power source is used during calibration and the Multimeter is then used on 60 Hz AC, the infinity reading will be "OVER" and approximately ".35." This is due to the count period being approximately 2 ms shorter in the latter case.

( ) Turn switch SW1 to the DCV position.

( ) Clip the black test lead to the DC CAL TP.

( ) Adjust the DC CAL control until the readout matches the value of the calibration voltage as recorded on the transformer insulator.

( ) Remove the test lead clip from the DC CAL test point.

( ) Return to the "ZERO ADJUST" section on Page 39, and repeat all the previous steps until the correct readings are obtained to this point. NOTE: Because of interaction between controls, you may have to perform these steps several times.

AC VOLTS CALIBRATION

( ) Set the front panel switches in the following positions.

SW1: DCV
SW2: 20

( ) Touch the test lead tip to AC CAL TP and adjust the AC TP ADJ control (next to the AC TP) for a readout of 16.3.

NOTE: The readout may vary between 16.2, 16.3, and 16.4. A proper adjustment will cause it to read 16.3 most of the time.

( ) Remove the probe from the AC CAL TP.

( ) Turn switch SW1 to the ACV position.

( ) Touch the test lead tip to the AC CAL TP again and allow the display to stabilize.

( ) Adjust the AC CAL control (at the rear of the circuit board) for a meter reading of "OVER 0.0."

NOTE: The readout may vary between 19.9, "OVER 0.0," and "OVER 0.1." A proper adjustment will cause it to read "OVER 0.0" most of the time.

( ) Repeat the previous four steps until the correct readouts are obtained in both switch positions.

( ) Remove the probe from the AC CAL TP.

OHMS CALIBRATION

( ) Turn switch SW1 to KΩ (200 Ω).

( ) ~~Remove the black test lead from lug 7F of switch SW1 and clip the lead on lug 2 of fuse F1.~~

You will calibrate the five ohms ranges in the following steps. Touch the black test lead tip to the indicated OHMS CAL TP (test point) for each range and adjust the indicated control for an "OVER 00" readout. The decimal point should be at the indicated position as shown under "Meter Reading" in the following chart.

see
Change

Range Switch	OHMS CAL TP (Test Point)	Control	Meter Reading
( ) (200 Ω)	200	200 ADJ	"OVER 00"
( ) 2	2 k	2000 ADJ	"OVER .00"
( ) 20	20 k	20 k ADJ	"OVER 0.0"
( ) 200	200 k	200 k ADJ	"OVER 00"
( ) 2 K	2 M	2 M ADJ	"OVER .00"

( ) Repeat the previous five steps as many times as necessary until you obtain a stable reading for each switch position.

( ) Turn off the multimeter.

( ) Remove the test lead.

This completes the "Initial Tests and Calibration" section of the Manual. Disconnect the AC line cord from the power source and proceed to the "Final Assembly" section.

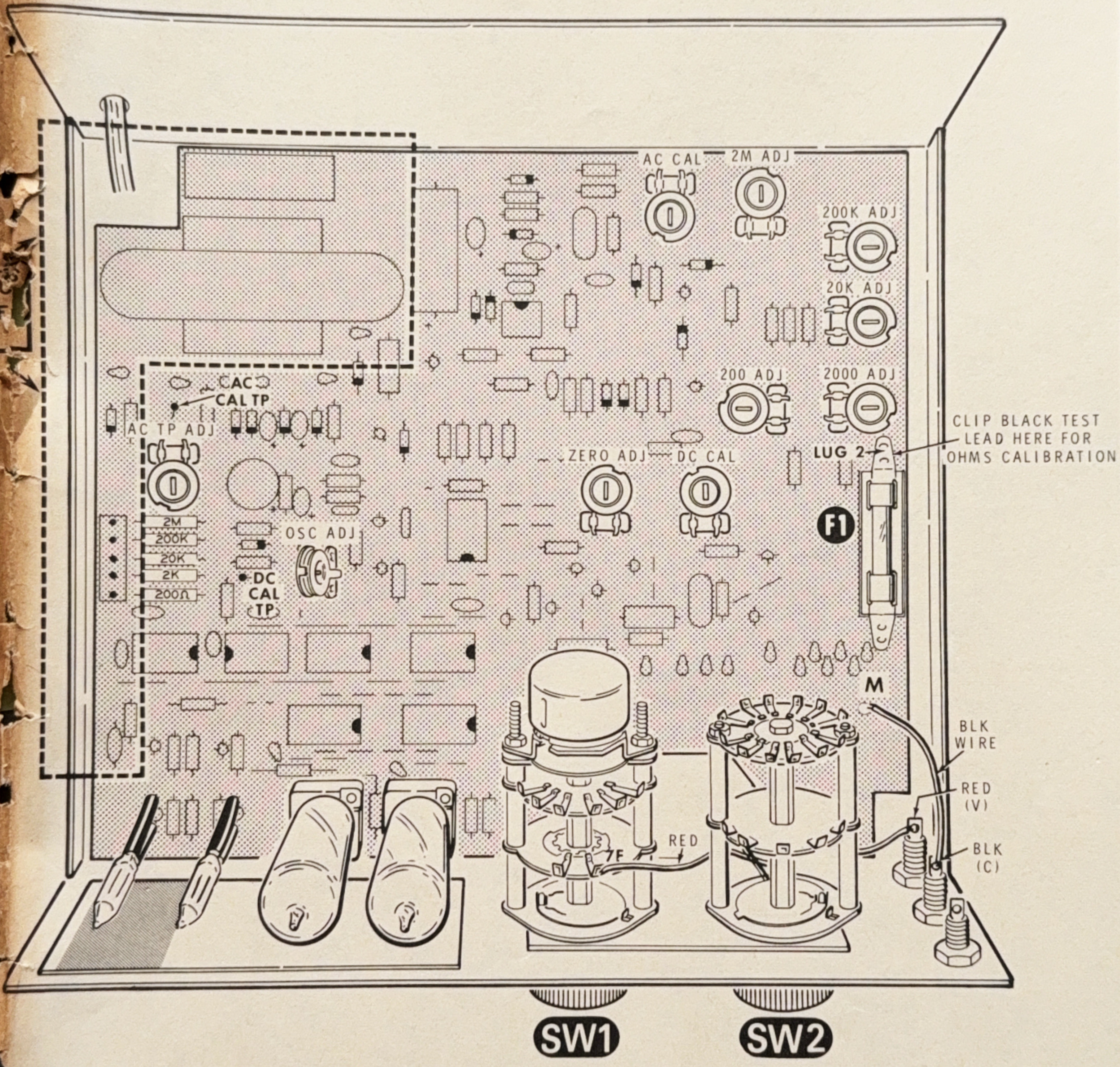
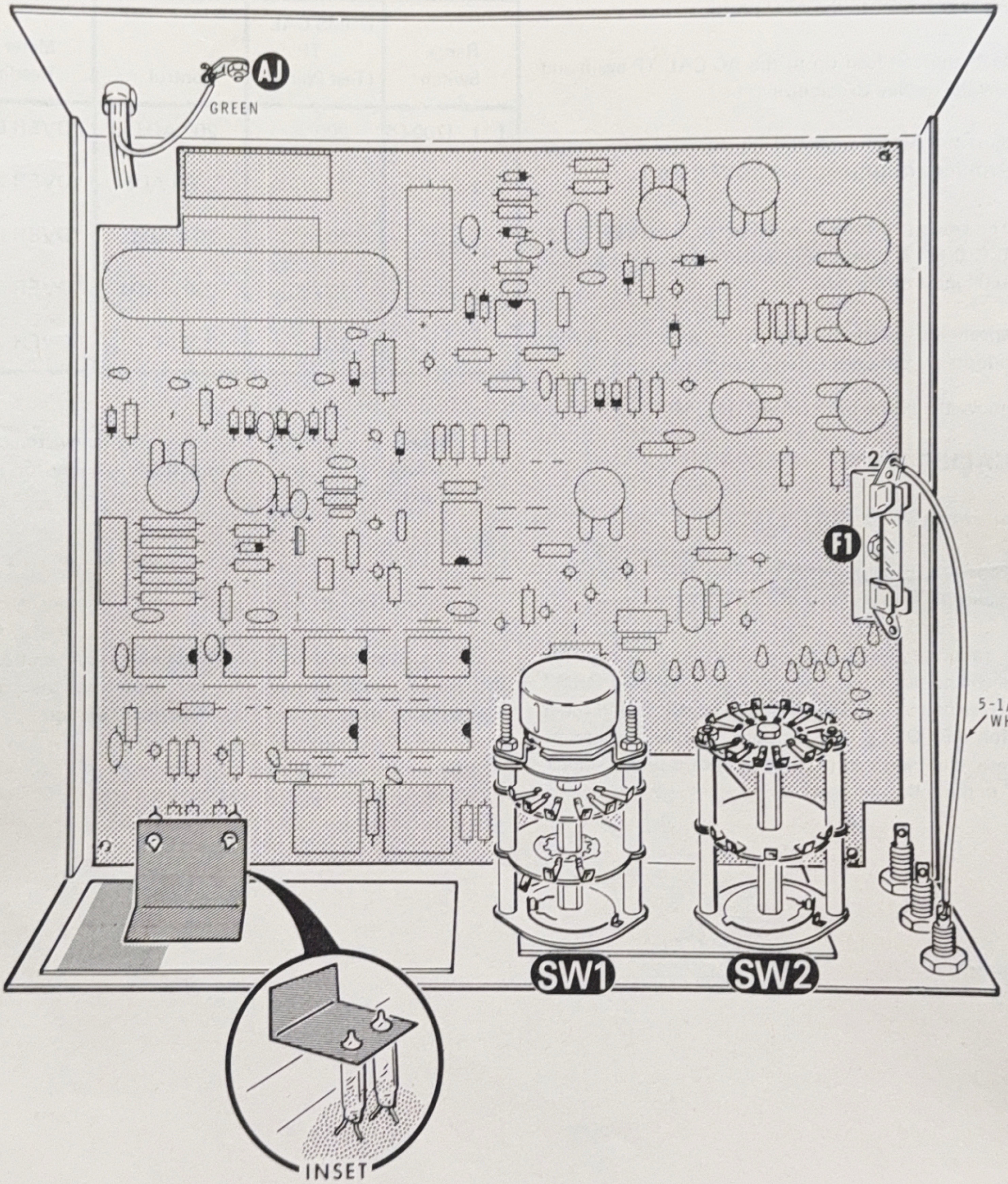

AC CAL
2M ADJ
200K ADJ
20K ADJ
200 ADJ
2000 ADJ
CLIP BLACK TEST LEAD HERE FOR OHMS CALIBRATION
LUG 2
F1
AC CAL TP
AC TP ADJ
ZERO ADJ
DC CAL
2M
200K
20K
2K
200Ω
OSC ADJ
DC CAL TP
M
BLK WIRE
RED (V)
BLK (C)
7F
RED
SW1
SW2

Figure 2-2

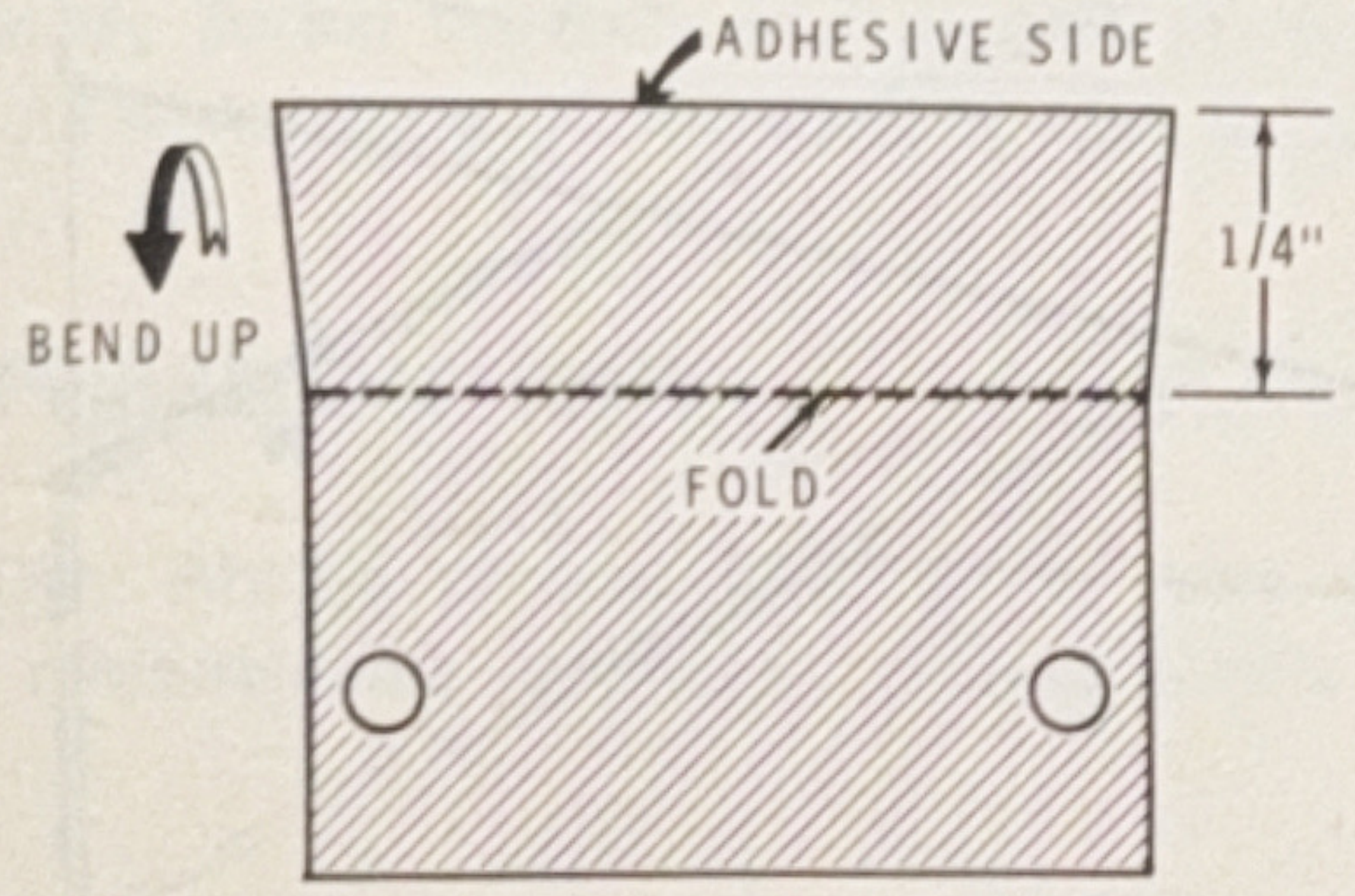


PICTORIAL 8-1

FINAL ASSEMBLY

Refer to Pictorial 8-1 for the following steps.

( ) Refer to Detail 8-1A and draw a line across the small lamp insulator 1/4" from the edge opposite the holes as shown.



Detail 8-1A

NOTE: When you fold the lamp insulator, the adhesive (paper backed) side must be on the bottom.

( ) Score the marked line (press heavy with a ball-point pen for example). Then bend the 1/4" portion upward as shown in the Pictorial.

( ) Remove the paper backing from the lamp insulator.

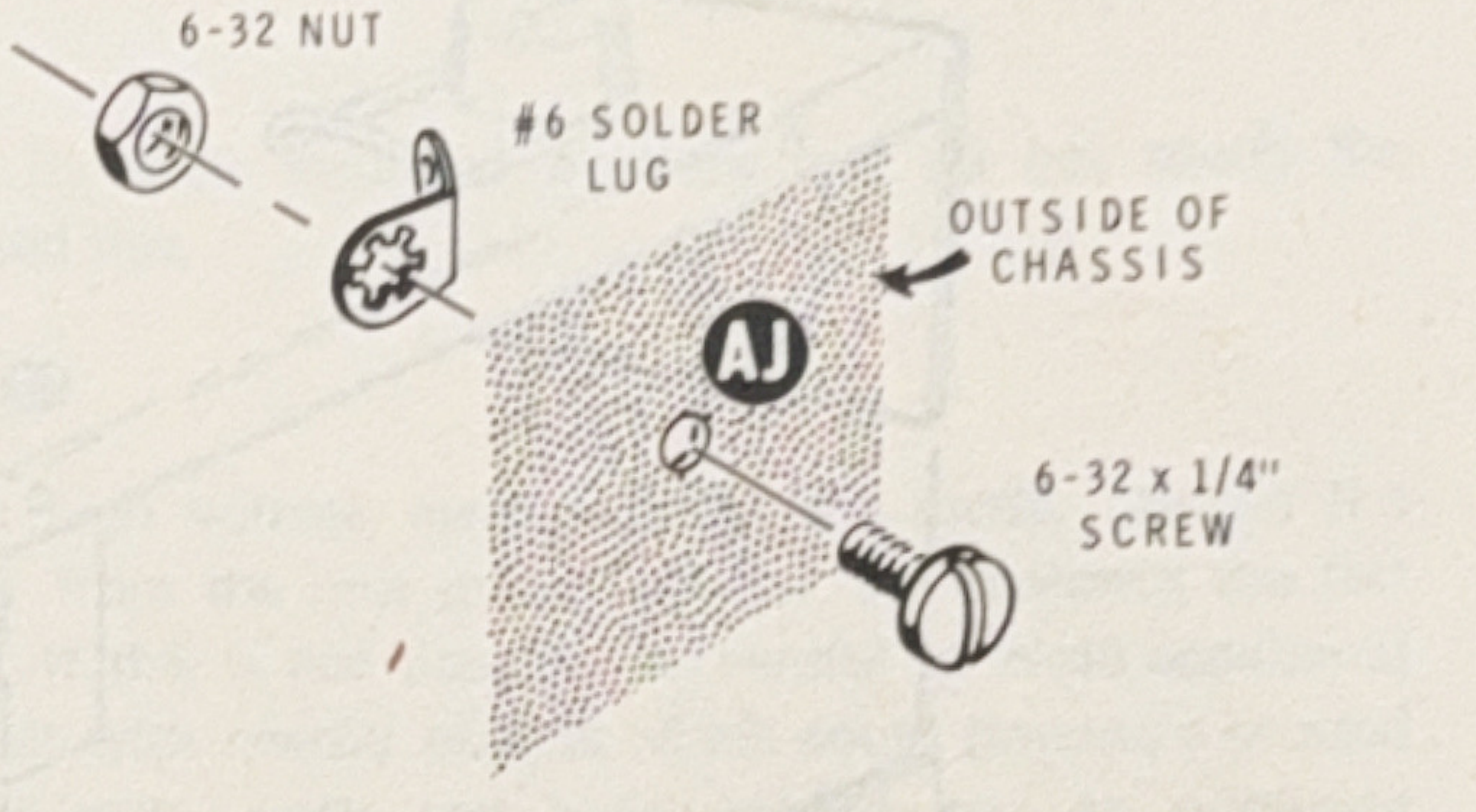
( ) Press the lamp insulator onto the tips of the two lamps as shown in the Pictorial. Be careful not to bend the lamp leads. Position the 1/4" fold toward the inside of the front panel.

( ) Firmly press the 1/4" fold against the inside of the front panel. Be sure both lamps are vertical.

( ) Prepare a 5-1/4" white wire.

( ) Connect this 5-1/4" white wire from the white input jack (S-1) to lug 2 of fuse F1 (S-1).

( ) Locate screw hole AJ in the rear panel. On the inside of the panel, scrape any paint from around the hole to assure a good chassis connection.



Detail 8-1B

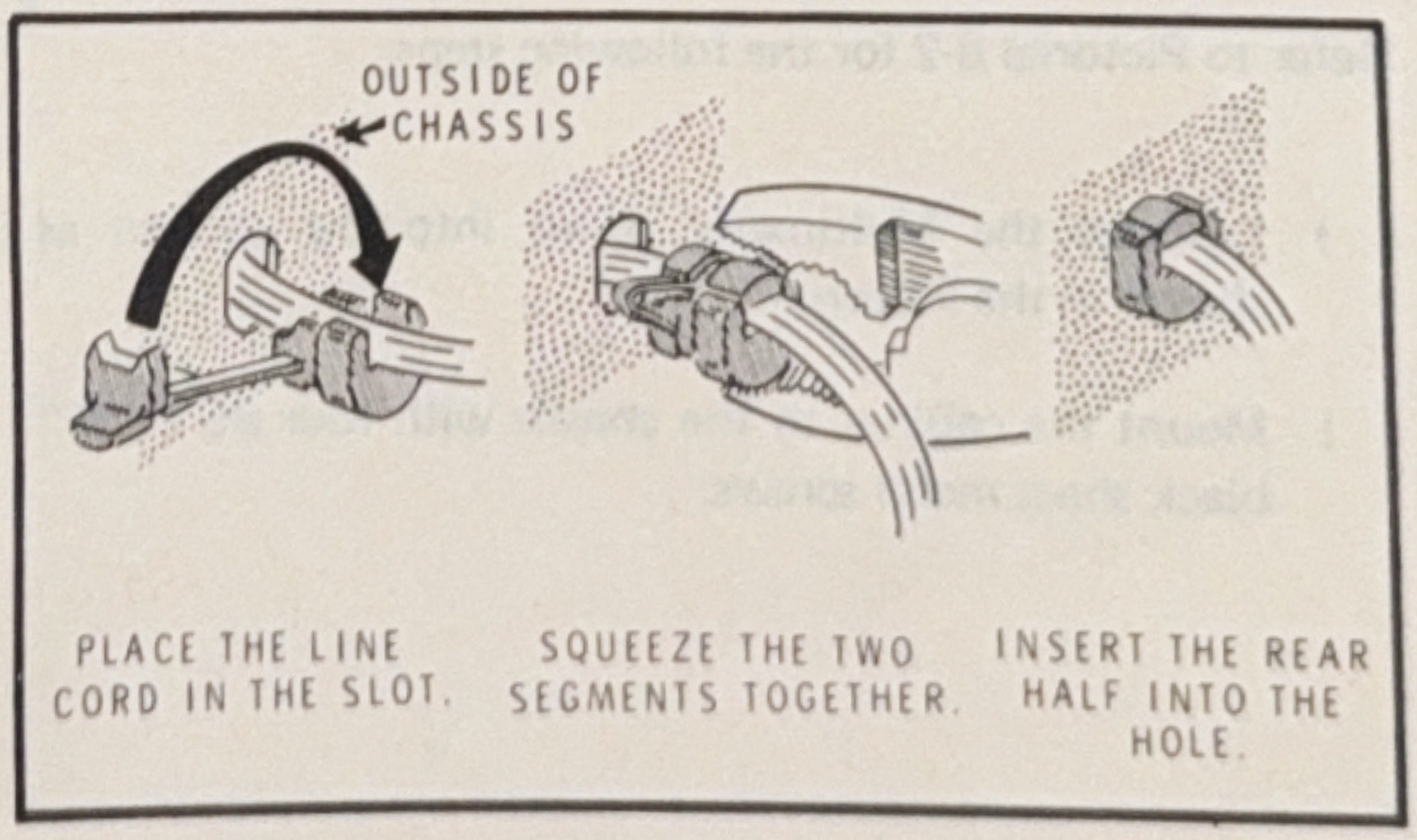
( ) Refer to Detail 8-1B and install a #6 solder lug at AJ. Use a 6-32 x 1/4" screw and a 6-32 nut. Position the solder lugs as shown in the Pictorial.

( ) Untie the green wire from the line cord and remove 1/4" of insulation from the end.

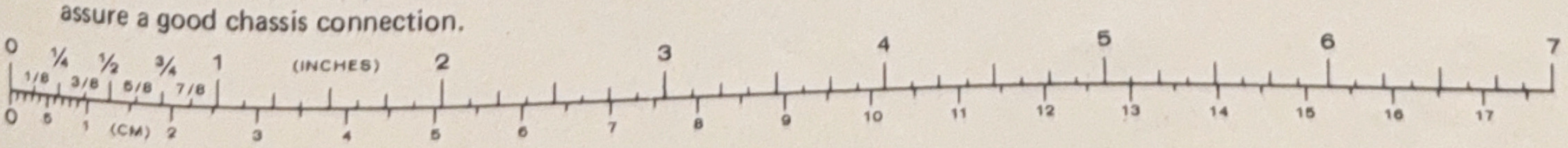
( ) Twist the small wire strands together and melt a small amount of solder on the strands.

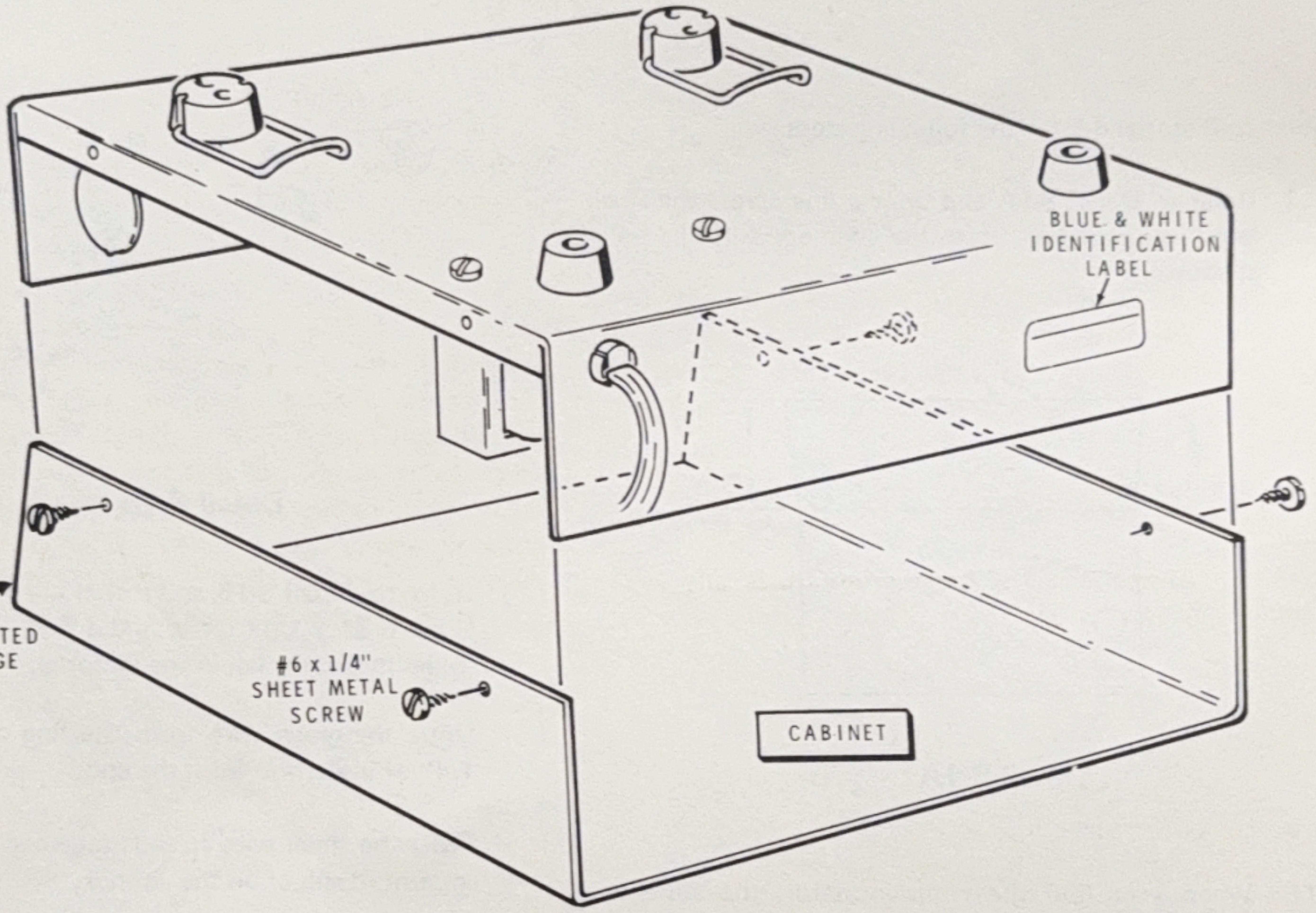
( ) Connect the green wire to solder lug AJ (S-1).

( ) Install the strain relief on the line cord as shown in Detail 8-1C.


OUTSIDE OF CHASSIS
PLACE THE LINE CORD IN THE SLOT.
SQUEEZE THE TWO SEGMENTS TOGETHER.
INSERT THE REAR HALF INTO THE HOLE.

Detail 8-1C


0 ¼ ½ ¾ 1 (INCHES) 2 3 4 5 6 7
1/8 3/8 5/8 7/8
0 5 1 (CM) 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17


BLUE & WHITE IDENTIFICATION LABEL
SLANTED EDGE
#6 x 1/4" SHEET METAL SCREW
CABINET

PICTORIAL 8-2

Refer to Pictorial 8-2 for the following steps.

( ) Position the Multimeter down into the cabinet as shown in the Pictorial.

( ) Mount the cabinet to the chassis with four #6 x 1/4" black sheet metal screws.

( ) Remove the backing paper from the blue and white identification label. Then press the label into place on the rear of the chassis as shown in the Pictorial. Be sure to refer to the numbers on this label in any communications you have with the Heath Company about this kit.

OPERATION

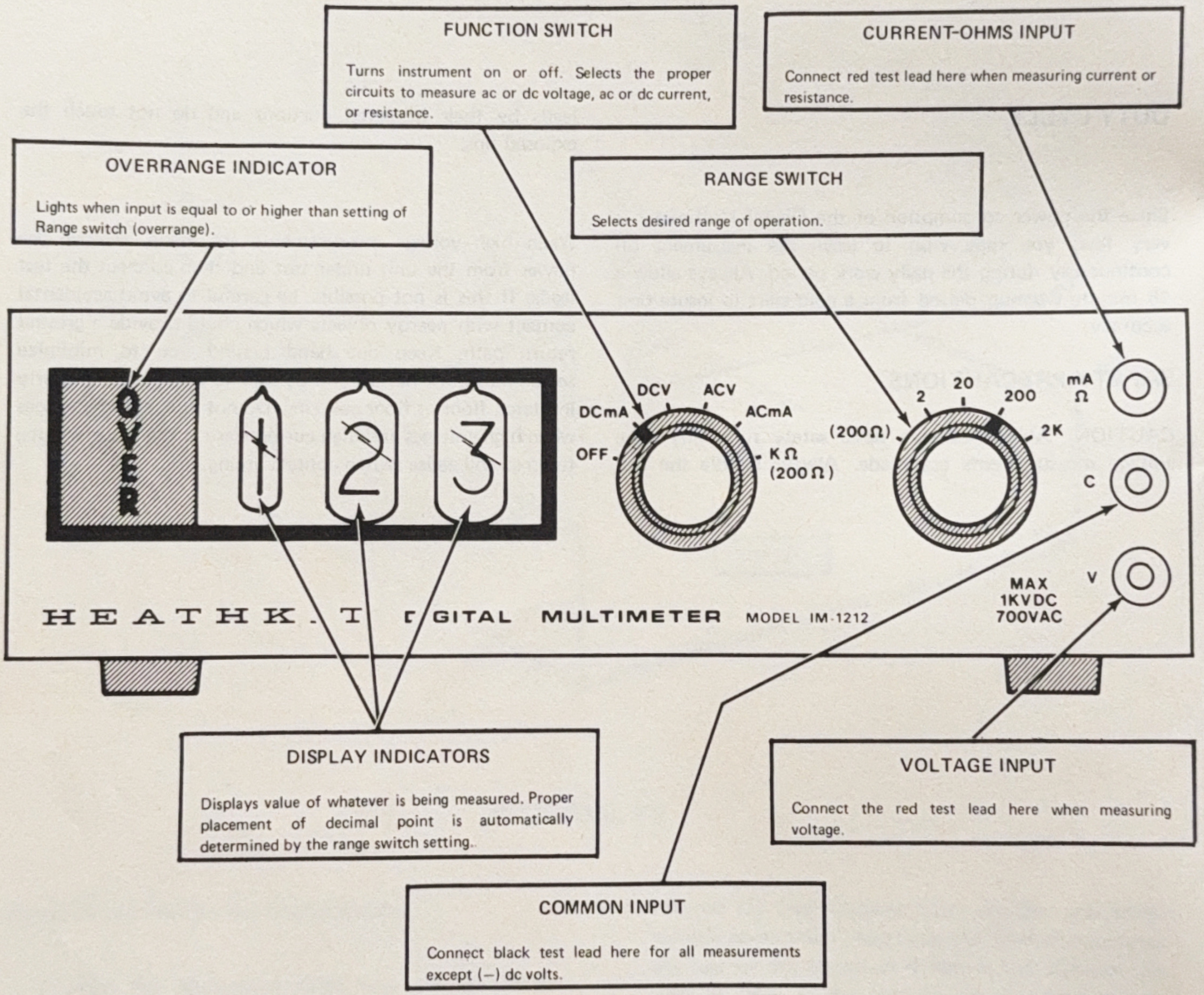
DUTY CYCLE

Since the power consumption of the Digital Multimeter is very low, you may wish to leave the instrument on continuously during the daily work period. Always allow a 15 minute warmup period from a cold start to insure best accuracy.

SAFETY PRECAUTIONS

CAUTION: Always observe basic safety rules any time voltage measurements are made. Always handle the test leads by their insulated portions and do not touch the exposed tips.

When high voltage measurements are made, remove the power from the unit under test and then connect the test leads. If this is not possible, be careful to avoid accidental contact with nearby objects which could provide a ground return path. Keep one hand behind you to minimize accidental shock hazard and be sure to stand on a properly insulated floor or floor covering. Do not switch meter ranges when high voltages and high currents are at the Meter inputs; to do so will cause switch contact arcing.



FUNCTION SWITCH

Turns instrument on or off. Selects the proper circuits to measure ac or dc voltage, ac or dc current, or resistance.

CURRENT-OHMS INPUT

Connect red test lead here when measuring current or resistance.

OVERRANGE INDICATOR

Lights when input is equal to or higher than setting of Range switch (overrange).

RANGE SWITCH

Selects desired range of operation.

DISPLAY INDICATORS

Displays value of whatever is being measured. Proper placement of decimal point is automatically determined by the range switch setting.

VOLTAGE INPUT

Connect the red test lead here when measuring voltage.

COMMON INPUT

Connect black test lead here for all measurements except (−) dc volts.

Figure 3-1

Measurements

Refer to Figure 3-1 while you read the following information.

CONNECTING THE MULTIMETER

Place the Function switch in the OFF position.

Plug the line cord into an AC outlet.

Plug the black test lead into the C (black) jack and the red lead into the other appropriate jack (mA Ω or V).

Follow the instructions (current, voltage, resistance, etc.) according to the type of measurement to be made.

Start with the highest range and work down.

DC CURRENT MEASUREMENTS

CAUTION: 3 amperes is the maximum DC current allowable on the 2 k mA range.

1. Set the RANGE switch to 2K or the desired lower range if it is known.

2. Set the FUNCTION switch to the DCmA.

3. Plug the red test lead into the mA–Ω jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately, as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on DCmA.	25% on all ranges.
2	.01 – 1.99	Over .50 (2.50) mA
20	0.1 – 19.9	Over 5.0 (25.0) mA
200	01 – 199	Over 50 (250) mA
2 K	.01 – 1.99	Over .50 (2.50) mA

NOTE: Reverse the test leads for –DC current measurements.

DC VOLTAGE MEASUREMENTS

CAUTION: Do not connect the C input to a potential greater than 500 volts above power line ground. This could damage the Multimeter.

1. Set the RANGE switch to 2K or the desired lower range.

2. Set the FUNCTION switch to DCV.

3. Plug the red test lead into the V jack and observe the readings. Lower the setting of the RANGE switch until you reach the proper range. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on DCV.	25% on all ranges except the 2K range.
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	0 1 – 199	Over 50 (250)
2K	.01 – 100 (1000)	None

NOTE: To make negative (–) DC voltage measurements, reverse the test leads.

AC VOLTAGE MEASUREMENTS

NOTE: When measuring AC voltage, any input other than a pure sine wave can cause an error because the AC converter is average-sensing and rms calibrated.

CAUTION: 700 volts rms is the maximum AC voltage allowable in the 2K range; 140 volts rms on the 2 (volt) range.

1. Set the RANGE switch to 2K or the desired lower range.

2. Set the FUNCTION switch to ACV.

3. Plug the red test lead into the V jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately, as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on ACV.	25% on all ranges except the 2K range.
2	.01 – 1.999	Over .50 (250)
20	0.1 – 19.99	Over 5.0 (25.0)
200	0 1 – 199.9	Over 50 (250)
2K	.01 – 70 (700)*	None

*Approximate rms value of 1000V peak.

AC CURRENT MEASUREMENTS

CAUTION: 3 amperes is the maximum AC current allowable on the 2K range.

1. Set the RANGE switch to 2K or the desired lower range if known.

2. Set the FUNCTION switch to ACmA.

3. Plug the red test lead into the mA–Ω jack and observe the reading. If the OVER lamp comes on, switch to a higher range immediately, as an overload condition exists. Otherwise, lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
(200 Ω)	Does not function on AC mA.	25% on all ranges.
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	0 1 – 199	Over 50 (250)
2K	.01 – 1.99	Over .50 (2.50)

RESISTANCE MEASUREMENTS

CAUTION: The resistance circuits of the Multimeter are protected against the application of AC and DC voltages up to a level which would cause a current of 3 amperes.

1. Set the RANGE switch to the desired range.

2. Set the FUNCTION switch to KΩ (200 Ω).

3. Plug the red test lead into the mA–Ω jack.

4. Connect the load to the test leads and observe the reading. Raise or lower the setting of the RANGE switch until the proper range is reached. The following table indicates the readout limits for each range.

RANGE	DISPLAY RANGE	ALLOWABLE OVERRANGE
		25% on all ranges.
(200 Ω)	01 – 199	Over 50 (250)
2	.01 – 1.99	Over .50 (2.50)
20	0.1 – 19.9	Over 5.0 (25.0)
200	0 1 – 199	Over 50 (250)
2K	.01 – 1.99	Over .50 (2.50)

IN CASE OF DIFFICULTY

WARNING: When the line cord is connected to an AC outlet, hazardous voltages will be present at several places. See Figure 2-2 (fold-out from Page 41).

Begin your search for any trouble that occurs after assembly by carefully following the steps listed in the "Visual Test" section. After visual tests are completed, refer to the "Troubleshooting Chart."

NOTE: Refer to the "Circuit Board X-Ray Views" on Page 59 for the physical location of parts on the circuit board.

VISUAL TEST

1. Recheck the wiring. Trace each lead in colored pencil on the Pictorial as it is checked. It is frequently helpful to have a friend check your work. Someone who is not familiar with the unit may notice something consistently overlooked by the kit builder.
2. Reheat all questionable connections to make sure they are properly soldered.
3. Check to be sure that all transistors are in their proper locations. Make sure each lead is connected to the proper point.
4. Check that each of the IC's are properly installed in their sockets, and that the pins are not bent out or under the IC. Also be sure the IC's are installed in their correct positions.
5. Check the values of the parts. Be sure in each step that the proper part has been wired into the circuit, as shown in the Pictorial diagrams. It would be easy, for example, to install a 680 Ω (blue-gray-brown) resistor where a 6800 Ω (blue-gray-red) resistor should have been installed.
6. Check for bits of solder, wire ends, or other foreign matter which may be lodged in the wiring.
7. A review of the "Circuit Description" may help you determine where the trouble is.

If the trouble is still not located after the visual tests are completed, and a voltmeter is available, check voltages against those shown on the Schematic. Read the "Precautions for Troubleshooting" (Page 51) before you make any measurement. NOTE: All voltage readings were taken with a high impedance voltmeter. Voltages may vary ±20%.

WAVEFORMS

The correct oscilloscope waveform patterns for various points in the Multimeter are provided on fold-out from Page 52. To use these patterns, you will need an oscilloscope capable of the horizontal sweep and vertical sensitivity settings listed in the chart, as well as a high impedance, low capacitance probe.

PRECAUTIONS FOR TROUBLESHOOTING

1. Be cautious when testing IC and transistor circuits. Although they have almost unlimited life when used properly, they are much more vulnerable to damage from excessive voltage or current than most other components.

2. Be sure you do not short any terminals to ground when making voltage measurements. If the probe should slip, for example, and short out a bias or supply point, it is very likely to damage one or more IC's, transistors, or diodes.

Troubleshooting Charts

Because the Digital Multimeter is fundamentally a DC voltmeter, the basic circuitry is used when the Function switch is in the DCV position, and conditioning circuits are added for other functions. Consequently, if a malfunction occurs, first check the circuitry used for the DC voltmeter function. If that is operating satisfactorily, check the circuitry added for other functions.

The following charts list malfunctions that could arise and some possible causes. Look at the "Problem" column and try to locate your difficulty. Then try to correct the difficulty by checking the "Possible Cause" column.

Use charts #1 or #2 if any malfunction should arise in the DCV position. Use chart #3 if any malfunction should arise in any of the remaining positions. If a particular part or parts are mentioned (transistor Q2 for example, or resistor R6) as a possible cause, check these parts to see if they are incorrectly installed or wired. Check to see if an improper part was installed at that location. It is also possible at times for a part to be faulty.

Refer to the pages associated with the Schematic Diagram for IC basing diagrams and a cross reference table of manufacturers' numbers.

NOTE: Some of the circuits use IC's of the same type. An IC thought to be faulty can often be interchanged with one known to be good.

The following two charts are for the DCV position. Chart #1 deals with the possibility of a malfunction that prevents the neon lamps or readout tubes from lighting or stabilizing. In chart #2, you will make measurements to check out the DCV position of the Function switch. Chart #3 is for all remaining positions.

CHART #1

PROBLEM	POSSIBLE CAUSE
Neon lamps and readout tubes do not light.	1. Power line fuse blown. 2. Diode D16. 3. Function switch in OFF position. 4. Function switch miswired.
Readout tubes light but are dim and all ten digits come on.	1. Transistor Q11 and its associated resistors, capacitors, and diodes.
A particular digit lights. However, all numerals appear dimly lit. (For example, a "3" condition always faintly lights 0 through 9.)	1. Open tube socket pin. 2. Open decoder driver pin(s) IC3 or IC4.
Readout does not read 00 with inputs shorted.	1. Zero Adjust control not set properly. 2. Integrated circuit IC8 not producing reset pulse.
Readout counts up continously.	1. Transistor Q12. 2. Integrated circuit IC8 not producing reset pulse.
Readout does not stabilize after warmup time.	1. Diode D17; transistors Q12, Q15, Q16; or an associated resistor or capacitor.
"1" or "Over" lamp comes on when inputs are shorted.	1. Transistor Q13 or Q14. 2. Integrated circuit IC5.
Two or more digits in a readout tube on at the same time.	1. Solder bridge at readout tube socket. 2. Solder bridge at IC3 or IC4 sockets. 3. Interchange readout tubes. 4. Interchange IC3 with IC4.
Oscillator does not adjust to "Over .85," ±15 digits.	1. Resistors R206 and R208. 2. Control R207. 3. Interchange capacitors C201 and C203.
Reads "00" all the time.	1. IC8 installed backward.

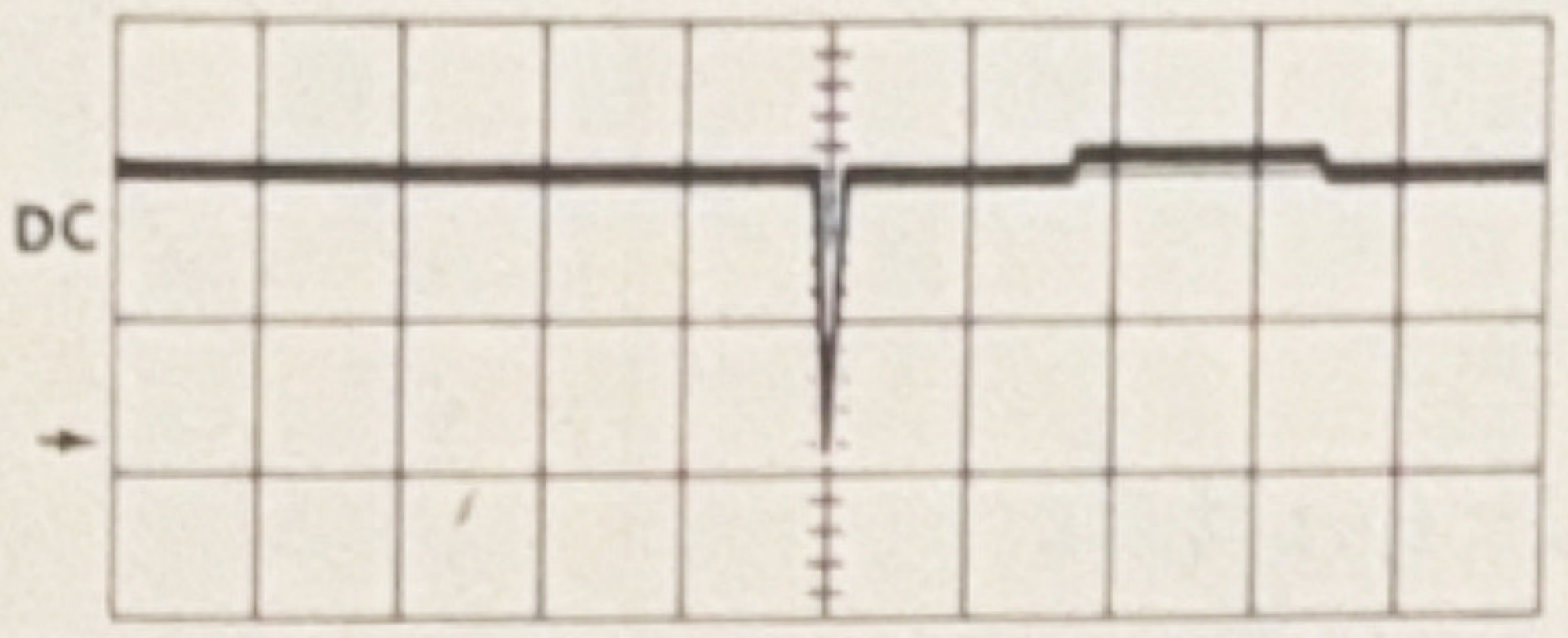
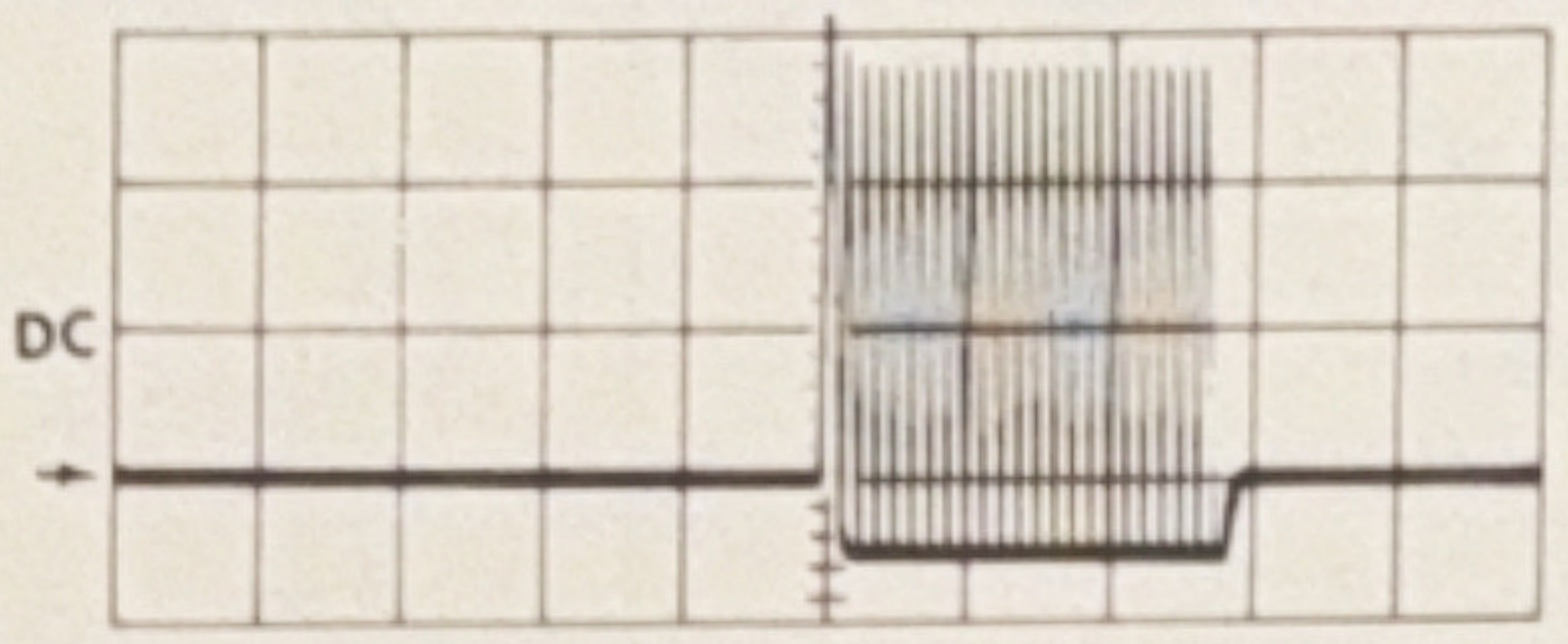
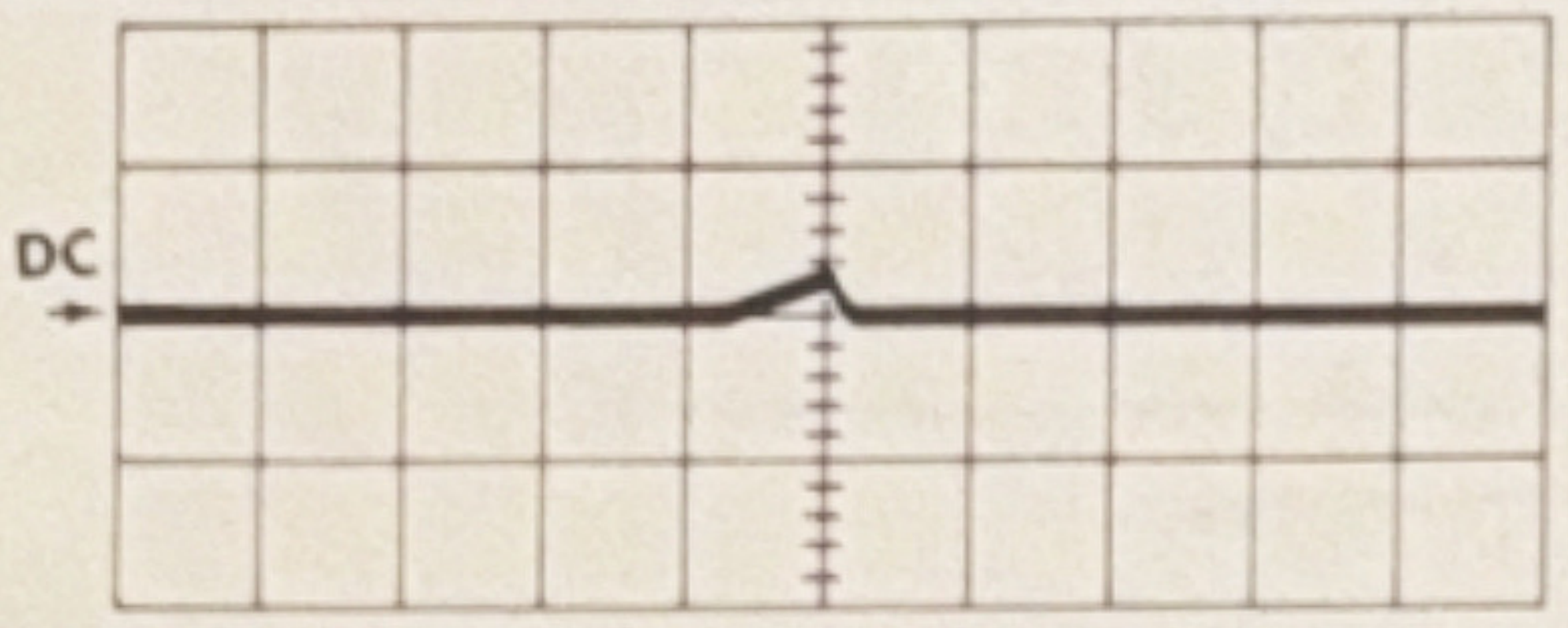
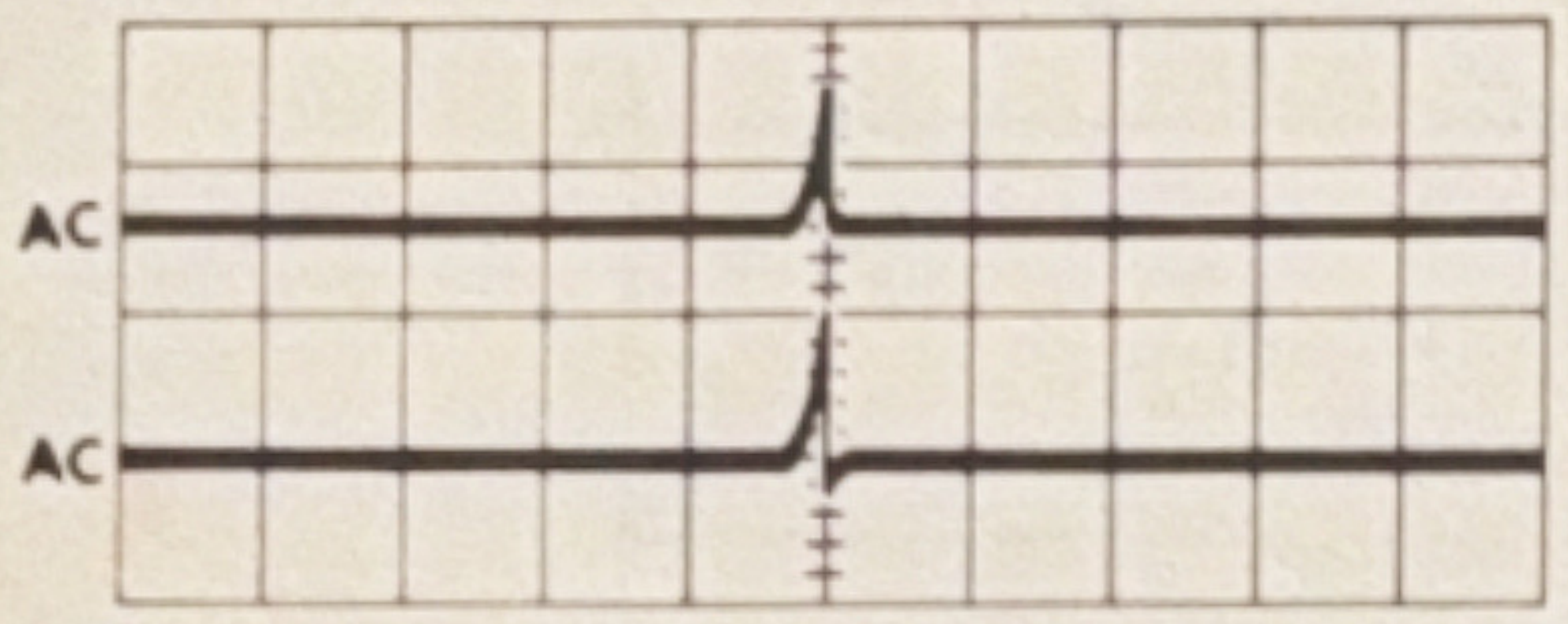
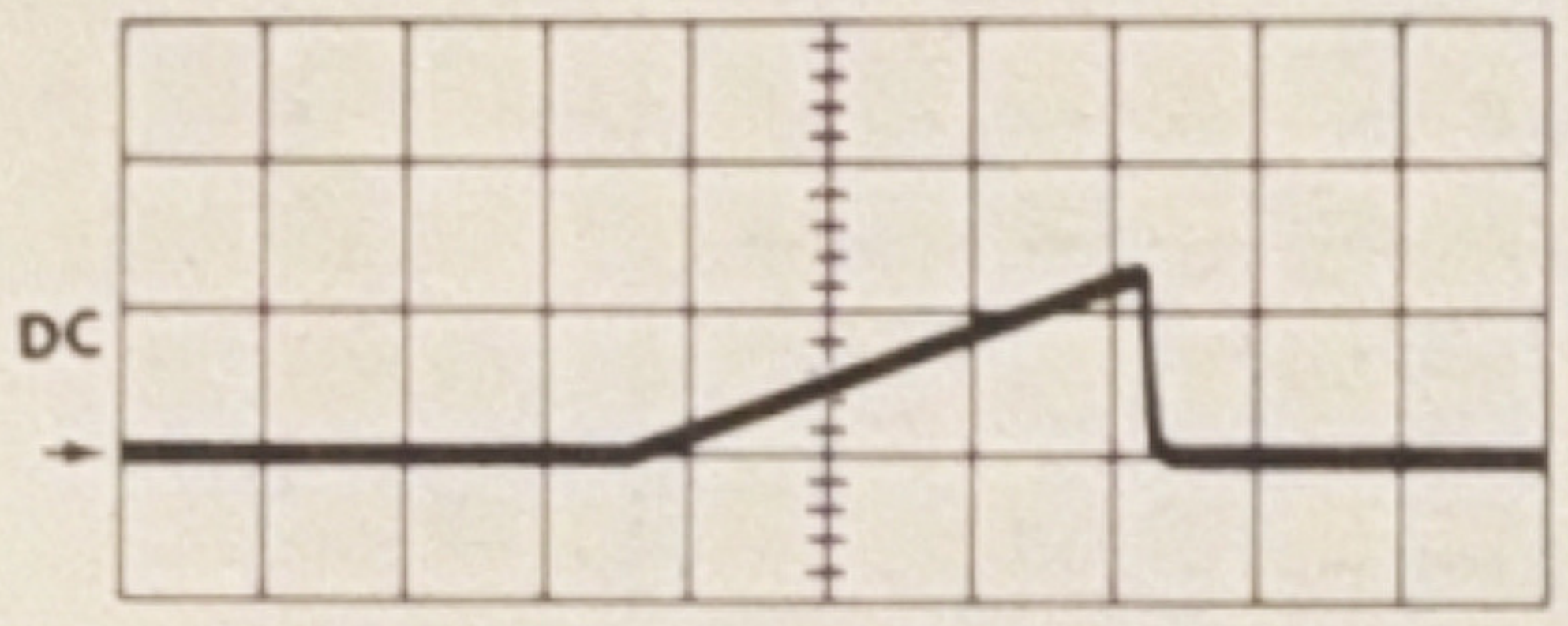
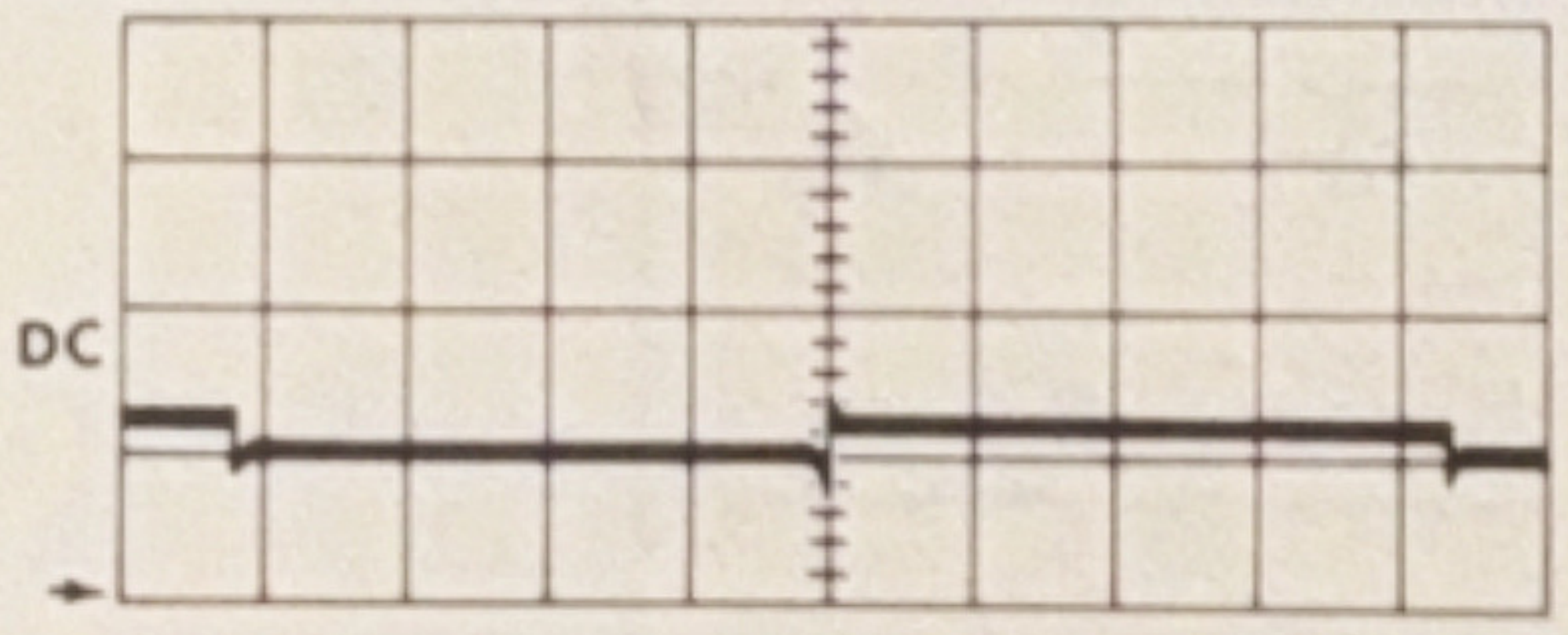
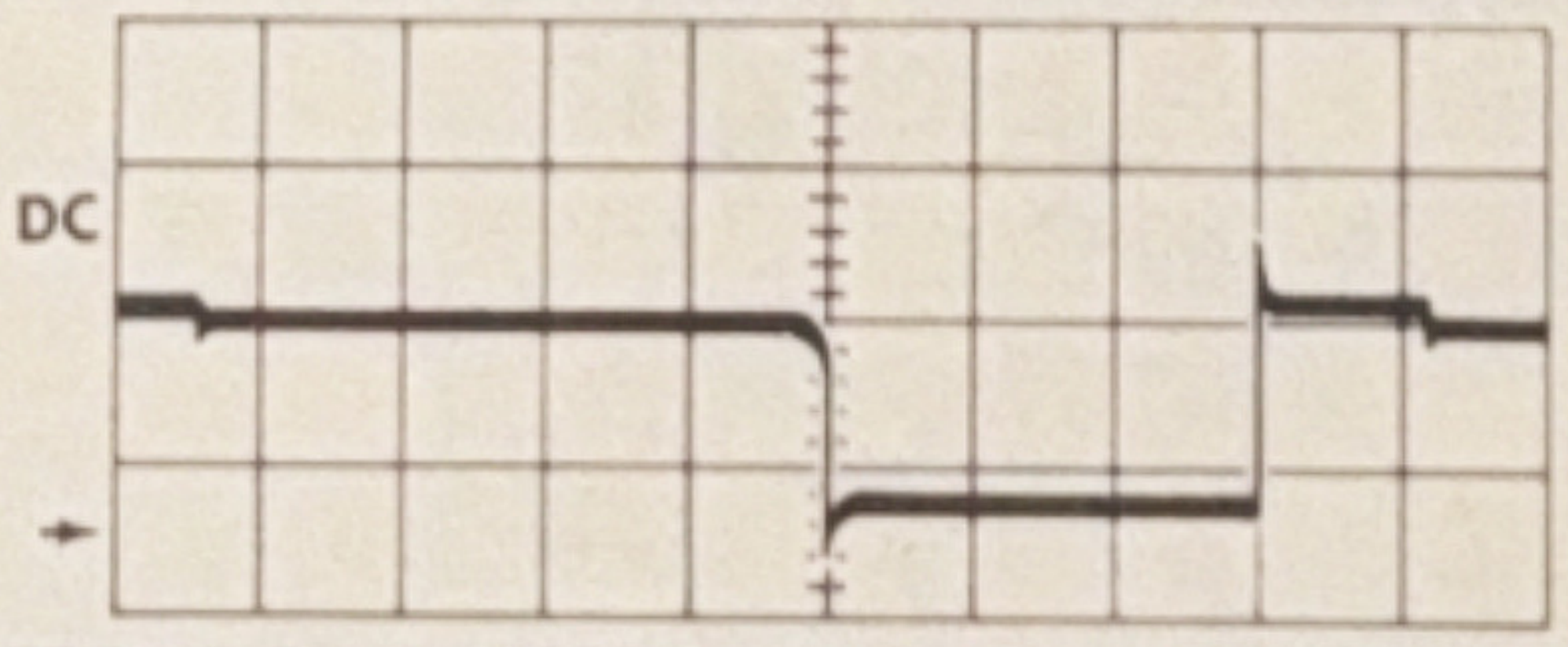
CHART #2

RED LEAD (V INPUT) TO:	FUNCTION SWITCH	RANGE SWITCH	PROBLEM	POSSIBLE CAUSE
Black lead (C input)	DCV position	2 position	Readout does not read .00.	1. Integrated circuit IC8 not producing reset pulse. 2. Transistor Q11 and its associated resistors, capacitors, and diodes. 3. Diode D17. 4. Integrated circuit IC6 or IC7. 5. Integrated circuit IC3 or IC4.
DC CAL TP			Readout does not read the value stamped on the voltage reference source package.	1. Transistors Q1 through Q7. 2. Integrated circuit IC2. 3. Transistor Q12, Q15, or Q16. 4. Transistor Q11 and its associated resistors, capacitors, and diodes. 5. Diode D17. 6. Integrated circuit IC6 or IC7. 7. Integrated circuit IC3 or IC4. 8. Instrument not calibrated. 9. Resistor R146.

CHART #3

FUNCTION SWITCH POSITION	PROBLEM	POSSIBLE CAUSE
DC mA	Readout does not seem to read correctly.	1. Resistors R101 through R109.
ACV		1. Transistor Q8 or integrated circuit IC1.
AC mA		1. Resistors R101 through R109. 2. Transistor Q8 or integrated circuit IC1.
KΩ (200 Ω)		1. Controls R111, R113, R115, R117, or R119 not adjusted properly. 2. Resistors R111 through R119, or R121 wrong value. 3. Transistor Q9 or Q10, or diode D1, D2, or D3.

WAVEFORMS

	TEST POINT	OSCILLOSCOPE		INPUT COUPLING	Waveforms (DC zero-volt reference point indicated by arrowhead)	POSSIBLE CAUSE OF IMPROPER WAVEFORM
		Vertical: Volts/cm	Horizontal: m sec			
1	IC8, pin 11	2	2	DC		1. Pin 13 not held high (+5 VDC). 2. IC8. 3. Solder bridge.
2	IC7, pin 14 (2 VDC input)	2	2	DC		1. No signal from transistor Q15. 2. Solder bridge.
3	Q1, base (input shorted)	2	2	DC		1. Capacitor C106. 2. Transistor Q5 "on" (emitter negative to base and collector). 3. Transistor Q7.
4	IC2: (input shorted) Pin 6 Pin 12	 .5 .5	 1 1	 AC AC		1. Pin 6: A. Transistor Q1 or Q4 (check voltages). B. Control R152 misadjusted. Pin 12: A. Transistor Q2, Q3, or Q6 (check voltages). B. Control R152 misadjusted.
5	Q1 base (2 VDC input)	2	2	DC		1. Transistor Q1. 2. Check for input to Q1 base. 3. Check meter switch positions. 4. Should be 1 MΩ from V panel jack to Q1 emitter.
6	D17 anode (input shorted)	1	2	DC		1. Diode D17. 2. Control R204 or R210. 3. IC2.
7	D17 anode (2 VDC input)	1	2	DC		1. Refer to step 6.

Oscilloscope Waveform Patterns

To check for the presence of waveforms shown in the chart (fold-out from this page), use an oscilloscope capable of the settings given. Set up the oscilloscope for line triggered sync and use a high impedance, low capacitance probe.

1. Set the Multimeter as follows:

   A Set the Function switch at DCV.

   B Set the Range switch at 2.

2. Connect the common lead of the oscilloscope to the C input jack on the Multimeter.

3. Adjust the oscilloscope for the designated vertical and horizontal settings for the waveform to be observed.

4. Connect or touch the oscilloscope probe tip to the test point and compare the pattern to the one in the chart. If you do not obtain the proper waveform, look at the "Possible Cause of Improper Waveform" column to determine the problem.

SPECIFICATIONS

Functions	DC volts, DC current, AC volts, AC current, ohms.
Ranges (Full Scale)	DC volts: 0-2, 20, 200, 1,000 V. DC current: 0-2, 20, 200, 2,000 mA. AC volts: 0-2, 20, 200, 700 V rms (25 Hz to 10 kHz). AC current: 0-2, 20, 200, 2,000 mA rms (25 Hz to 10 kHz). Ohms: 0-200, 2K, 20K, 200K, 2,000K (2M) ohms.
Overrange	25% on all functions, within maximum input limits.
Maximum Input	3 amperes into AC or DC mA, and Ohms (fuse protected). 700 VAC rms into Volts (except 2 V range; 140 VAC rms). 1000 VDC into Volts (except 2 V range: 200 VDC).
Resolution (low range)	Volts: 10 mV. Current: 10 μA. Ohms: 1 ohm.
Display	2-1/2 digit numeric.
Accuracy (Full Scale ±1 digit)	DC volts ±1%. DC current ±1.5%. AC volts ±1.5%. AC current ±1.5%. Ohms ±2%.
Input Impedance	1 megohm on all voltage ranges. 2 V drop maximum on current ranges.
Sample Rate	Line frequency.
Power Requirements	110-130 VAC/220-260 VAC, 50/60 Hz, 8 watts.
Fuse Requirements	Input: 3AG, 3 Ampere. Line: 3AG, 1/8 Ampere (1/16 Ampere for 240 VAC).
Dimensions (overall)	3-1/4" high, 9-1/2" wide, 8-3/4" deep. (8.25 cm high, 24 cm wide, 22.2 cm deep)
Weight	5 pounds (2.3 kg).

CIRCUIT DESCRIPTION

Refer to the Schematic Diagram (fold-out from Page 63) while you read the following description.

To help you locate parts in the Meter or on the Schematic, the resistors, capacitors, and other components are numbered as follows:

100 – 199 and 200 – 299 Parts mounted on the circuit board.

NOTE: Transistors, diodes, integrated circuits, and tubes are numbered without regard to specific grouping.

Selected inputs of resistance, current, or voltage to be measured, are directed through the contacts of the Function switch and through the scaling networks of the Range switch to the input of the A to D (analog-to-digital) converter. Inputs other than DC volts are directed through conversion circuits. The result of switching, scaling, and conversion is that all inputs are converted to a proportional DC voltage level acceptable by the A to D converter.

The analog-to-digital converter converts the input DC voltage to a pulse count during a time period. This time period allows a clock oscillator to generate a number of pulses which are directly proportional to the DC input level. After passing through the decade divider and the decoder driver cicuits, the number of gated pulses from the clock oscillator are displayed by the digital readout tubes.

BASIC MEASURING CIRCUIT

The basic measuring circuit is a monopolar analog-to-digital converter using a single ramp technique along with a stable oscillator for a long-term accuracy. All inputs are converted to +DC volts before being applied to the A to D converter. Full scale input voltage to the A to D converter is +2 volts DC, regardless of the selected function or range.

If the input exceeds 2 volts DC, it is scaled down to 2 volts or less by the Range switch before it enters the converter. AC voltages are converted to +DC by an average-sensing, rms calibrated operational rectifier circuit. When DC current is measured, a precision resistor is placed in shunt with the input to the A to D converter. For AC current, the shunt resistor is placed across the input to the AC converter. The voltage developed across the shunt resistor is thus measured, rectified if AC, and applied to the input of the A to D converter.

Resistance is measured by routing a calibrated constant current through the unknown resistance. The voltage drop developed across the unknown resistance is applied to the input to the A to D converter.

Timing for the conversion and readout circuits is controlled by the cyclic rate of the AC line frequency. The display tubes are illuminated only during the positive portions of the half-wave rectified high voltage pulses, and the A to D converter is cut off and no oscillator pulses are generated during this time. During the zero-level portion of the rectified high-voltage pulses, the readout is extinguished and a pulse is generated to reset the decade dividers to zero. Then the clock oscillator output is counted. The pulses are routed to the decoder network and applied to the readout tubes before the next half-wave voltage disables the oscillator and turns on the display tubes.

The counting and readout time is equally divided, and both times occur in slightly less than 17 milliseconds for the 60 Hz line frequency, and in 20 milliseconds for a 50 Hz line frequency. Normal persistence of vision does not permit the eye to detect the on-off operation of the readout tubes. Thus the display appears to be constant to the observer and provides a pseudo type of memory for the count.

INPUT SWITCHING

DC Current

DC current is applied to the meter through the mA-Ω jack and the C jack on the front of the Meter. After passing through contacts on wafer 1 of switch SW1, the current is routed to lugs 1 and 3. As the current passes through lug 3 and through a shunt resistor (R106 through R109) selected by switch SW2, a voltage is developed across this shunt. This DC voltage is then applied through lug 1 on wafer 1 of SW1 to the input of the A to D converter (the emitter of transistor Q1).

DC Voltage

When a DC voltage is being measured, it is routed through the V input jack to lug 7 on wafer 1 of SW1 and through the switch contacts to lug 5. The voltage is then applied to a voltage divider network on switch SW2 that consists of precision resistors R101 through R104. A DC voltage developed across this divider, proportional to the input voltage, is routed through SW1 contacts and to the A to D converter input circuit.

AC Voltage

AC voltage is routed in the same manner as DC voltage through the input switching, until it passes through the voltage divider network, R101 through R104, on switch SW2 where a proportionate voltage is developed. This scaled AC voltage is then applied to the AC converter through lugs 16 and 14 of wafer 2 on SW1. The DC output of the AC converter is routed through lugs 7 and 9, to lug 1 on wafer 2 of SW1, and then to the input of the A to D converter.

AC Current

AC current is directed through the Function switch contacts and into the shunt resistors of switch SW2, where a proportional voltage is developed, as in the case of the DC current. This AC voltage developed across a shunt resistor is applied through the AC converter in the same manner as the AC voltage previously described. The resultant DC voltage is routed to the input of the A to D converter.

Resistance

When a resistance is being measured, the mA–Ω input lead is connected through lugs 1 and 3 on wafer 1 of SW1, to lugs 12 and 22 on wafer 2 of SW1. From this point, the unknown resistance is connected to the collector of constant current source transistor Q10, through resistor R132 and diode D2. Depending on the ohms range selected by SW2, a selected calibrated resistance is placed in the emitter circuit of transistor Q10 and controls the level of the constant current through the circuit. Calibration resistances are composed of resistors R111 and R112 in the 2M circuit, R113 and R114 in the 200K circuit, R115, and R116 in the 20K circuit, R117 and R118 in the 2K circuit, and R119 and R121 in the 200 Ω circuit. A constant current passed through the unknown resistance will develop a voltage that is proportional to the value of that resistance. This voltage is then applied through lugs 1 and 11 on wafer 2 of SW1, to the input of the A to D converter.

Ohms Constant Current Source

Transistors Q9 and Q10; diode D3; and resistors R111 through R119, R121, and R137 are the main components for the OHMS constant current source. Diodes D1 and D2 are protection devices to prevent destruction of this circuit if the input leads are inadvertently connected across a voltage source. Transistor Q9 is connected as a zener diode. Transistor Q9, diode D3, and resistor R137 will maintain a constant bias for Q10, which is determined by the current through the Q10 emitter resistors (R111 through R119 and R121). The variable resistors are adjusted to allow the correct amount of current to flow through Q10 and each of the standard calibration resistors to provide +2-volt DC level to be applied to the A to D converter for each range selected.

A 200 ohm resistor will require 10 milliamperes of current to develop a 2-volt drop across it. Therefore, resistor R119 is adjusted for a constant current of 10 mA when the Function switch is in the kΩ position, the Range switch is in the 200 Ω position, and a 200 Ω resistor is across the Ω and C input jacks of the Multimeter. Each of the remaining ohms ranges will divide the amount of constant current by ten so that as the range is decaded up, the current is decaded down to maintain a 2-volt DC level for full-scale readings on all five ranges.

AC Converter

The AC converter, which consists of transistor Q8, IC1, and the associated components, functions as an operational rectifier. The gain of the converter is such that the average rectified voltage of a sine wave will produce a DC voltage equal to the rms value of the applied input AC voltage. Capacitor C103 will prevent DC from entering the converter and diodes D4 and D5 are protection diodes to limit the input voltage for safe operation of source follower Q8 (a buffer stage). R153 is for DC stability, D8 and R154 provide negative feedback during negative inputs, and D9 and R155 provide negative feedback during positive inputs. R156 and R167 adjust the gain of IC1 to provide a DC voltage to the input of the A to D converter which is equal to the rms value of the AC voltage input to Q8. R129, R128, and C104 filter the half-wave voltage before it is applied to the A to D converter.

ANALOG-TO-DIGITAL CONVERTER

Refer to the waveshapes in Figure 3-2 below while you read the following information.

When a DC voltage is applied to the emitter of transistor Q1, the A to D converter will function as follows:

During time T1 (waveform A), the display is illuminated and the A to D converter is disabled. At the start of T2, the display is extinguished and the base of transistor Q5 goes low (waveform F). This removes the short across capacitor C106 and allows C106 to take on a charge by the current from transistor Q7, a constant current source. This charge is in the form of a ramp (waveform C).

The termination of time T1 also produces a reset pulse (waveform G) to clear the counting circuit (IC's 5, 6, and 7) to zero for the start of another count. At the end of time T2, the voltage across capacitor C106 is at a level that permits transistor Q2 to conduct, lowering the voltage at its collector. This lower voltage at Q2's collector is inverted and amplified by transistor Q6 and applied to the input of IC2, which is wired as an R-S (Set-Reset) flip-flop (see Figure 4-1). The "high" at the reset input, pin 12, produces a "low" at the $\overline{Q}$ output, pin 13. This, in turn, turns off transistor Q3 and then transistor Q2. This forms a short start pulse (waveform D) and produces a "low" at the base of transistor Q12 (waveform J), which removes the short from clock oscillator transistors Q16 and Q15 and allows the oscillator to produce a series of pulses until a stop pulse is generated to disable the oscillator.

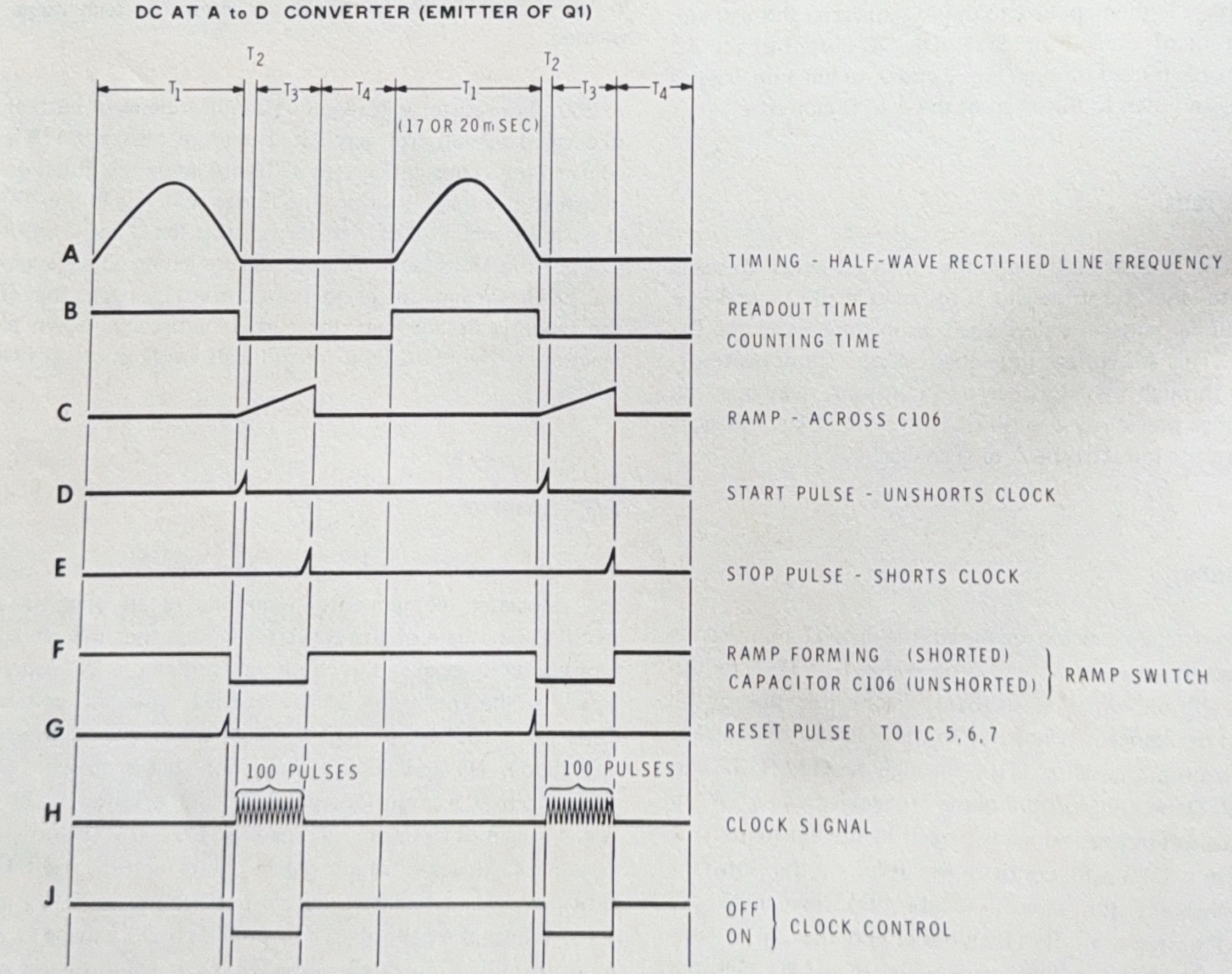

DC AT A to D CONVERTER (EMITTER OF Q1)
T2
T2
T1
T3
T4
T1
T3
T4
(17 OR 20 mSEC)
A
B
C
D
E
F
G
H
J
TIMING - HALF-WAVE RECTIFIED LINE FREQUENCY
READOUT TIME
COUNTING TIME
RAMP - ACROSS C106
START PULSE - UNSHORTS CLOCK
STOP PULSE - SHORTS CLOCK
RAMP FORMING (SHORTED)
CAPACITOR C106 (UNSHORTED)
RAMP SWITCH
RESET PULSE TO IC 5, 6, 7
100 PULSES
100 PULSES
CLOCK SIGNAL
OFF
ON
CLOCK CONTROL

Figure 3-2

As an example, assume a 1-VDC input to the emitter of transistor Q1. This will cause a display of 100 on the readout tubes. When the ramp amplitude reaches the Q1 emitter voltage, plus the .6 to .8 volt forward base-to-emitter drop, Q1 will conduct and quickly lower the Q1 collector voltages. This negative-going pulse is inverted by transistor Q4, which places a "high" on the input of the Stop R-S flip-flop, pins 1 through 6 (see Figure 4-1). The output (pin 1 of IC2) of the Stop R-S flip-flop will go high and allow transistor Q5 to conduct and discharge capacitor C106. This cuts off transistor Q1 to form the stop pulse (waveform E).

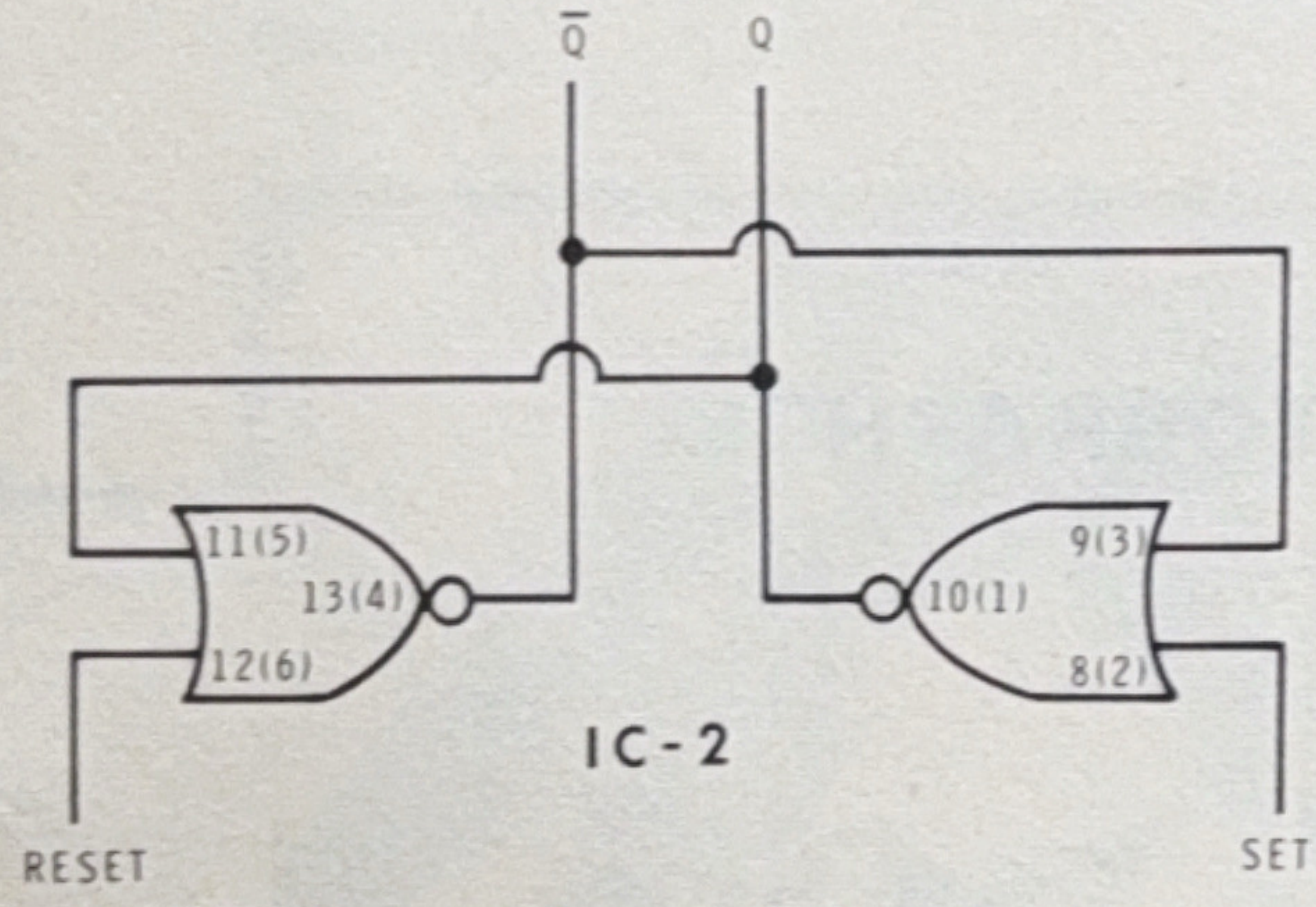


Figure 4-1

The start and stop R-S flip-flops form a latching circuit to control the switching operation of transistor Q12 (waveform J), which controls the on/off period of the clock oscillator (waveform H). The clock frequency is adjusted with R207 so that one volt of DC applied to the emitter of Q1 will produce 100 pulses at the input to the counter circuits.

BINARY TO DECIMAL READOUT

The output string of clock oscillator pulses from the collector of oscillator transistor Q15 is applied to pin 14 of decade counter IC7. In IC7 the pulses are counted, and every tenth pulse (carry pulse) is connected from output pin 11 to input pin 14 of IC6. Once again, each tenth pulse is applied from output pin 11 of IC6 to input pin 1 of IC5.

IC5 is a dual J-K flip-flop, each of which divides its input by two. This first carry pulse from pin 11 of IC6 will produce a "high" at pin 12, the Q output of FF1, allowing Q14 to conduct and illuminate DS202, the "ONE" lamp. The second pulse from IC6 will produce a low at FF1's Q output and extinguish the "ONE" lamp. The Q output of FF1 is connected to the CP input of FF2. The second pulse from the Q output of FF2 will produce a "high" at the base of transistor Q13 and complete the circuit for DS201 and illuminate the "OVER" lamp.

The reset pulse to clear IC5 requires a pulse opposite that of the two decade counters, IC6 and IC7. Therefore, the IC6 and IC7 reset pulse is inverted by IC8B before it is applied to IC5. In this manner, pulses are counted in units, tens, and hundreds in the decade counter IC's. Decoder drivers, IC3 and IC4, convert the binary count to decimal and drive the corresponding numerals in the readout tubes.

During the period in which the pulses are being coupled into the counter circuits, readout illumination is disabled by the absence of line frequency rectified pulses. When the binary information has been stored in the decoder drivers and the oscillator input is complete, the anode voltage to the readout tubes is raised to a high level and the appropriate numerals are illuminated. The repetition rate is such that the output display appears to be continuous to the observer.

POWER SUPPLY

The blue-leads winding of the power transformer, diodes D11 and D12, capacitor C114, zener diode D10, and transistor Q11 make up the regulated +5-volt DC power supply. The black lead of the transformer is the center tap for this full-wave winding and is connected to the Multimeter circuit ground. Transistor Q11 is a zener-controlled, Darlington, pass-transistor stage. The output voltage at the emitter of Q11 remains constant over a wide range of input voltage and output load and current. Diode D10 and resistors R148 and R149 are factory-selected components which provide an accurate, near-full-scale voltage reference for DC calibration.

The +15-volt and −15-volt supply consists of a secondary winding (with yellow leads) of the power transformer; diode D13; capacitors C117, C115, and C116; resistor R158; and zener diodes D14 and D15. Because of the uniformity of the current demand, a pass transistor is unnecessary. Resistor R151 limits the current to zener diode D10. The junction between zener diodes D14 and D15 center taps the supply voltage, and references both the positive and negative voltages to ground.

The power transformer winding with the red and black leads provides a secondary step-up voltage. This voltage enables the readout tubes to be fired at the proper time and also supplies the power for the neon lamps used to illuminate the "1", and "Over" symbols. The rectified AC pulses that control the oscillator and readout timing are derived from this circuit. The black transformer lead also connects this transformer circuit to the circuit and chassis ground.

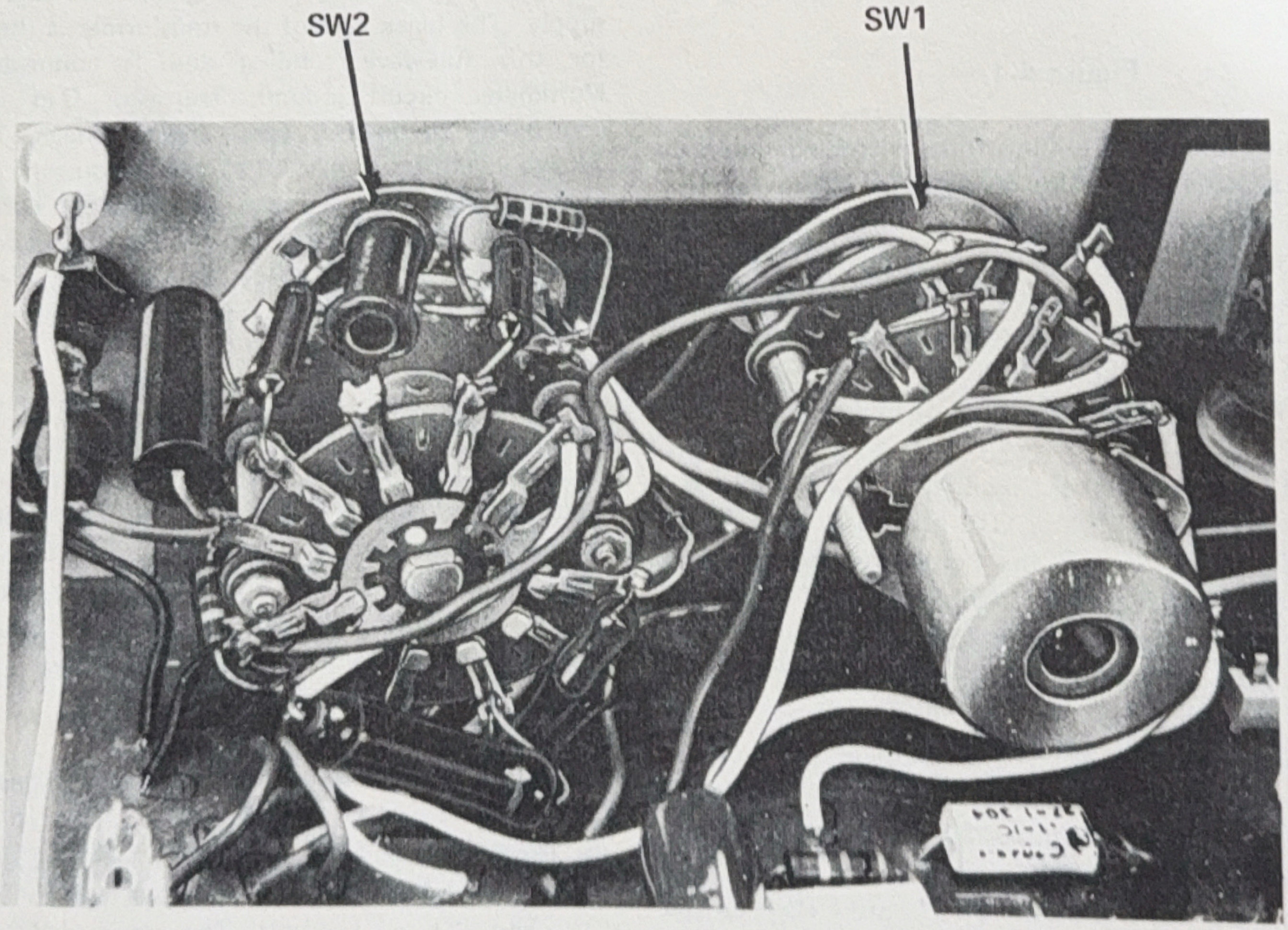
Resistors R161 and R163, plus AC TP ADJ control R162, provide the Meter with a transfer method for the calibration of the AC converter.

Resistors R218 and R219 in the pulse shaping network of IC8 form a voltage divider to attenuate the half-wave voltage to a level suitable to drive IC8.

The primary winding of power transformer T1 may be wired for a source voltage of either 120-volts or 240-volts AC, 50 to 60 Hz. Capacitor C118 connects the power line ground to circuit ground to eliminate shock hazard and to minimize A to D converter "hunt" while measuring any power line voltage or current.

Separate resistor standards on the circuit board; R123, R124, R125, R126, and R127, permit full-scale calibration of the Meter ohms ranges.

CHASSIS PHOTOGRAPH



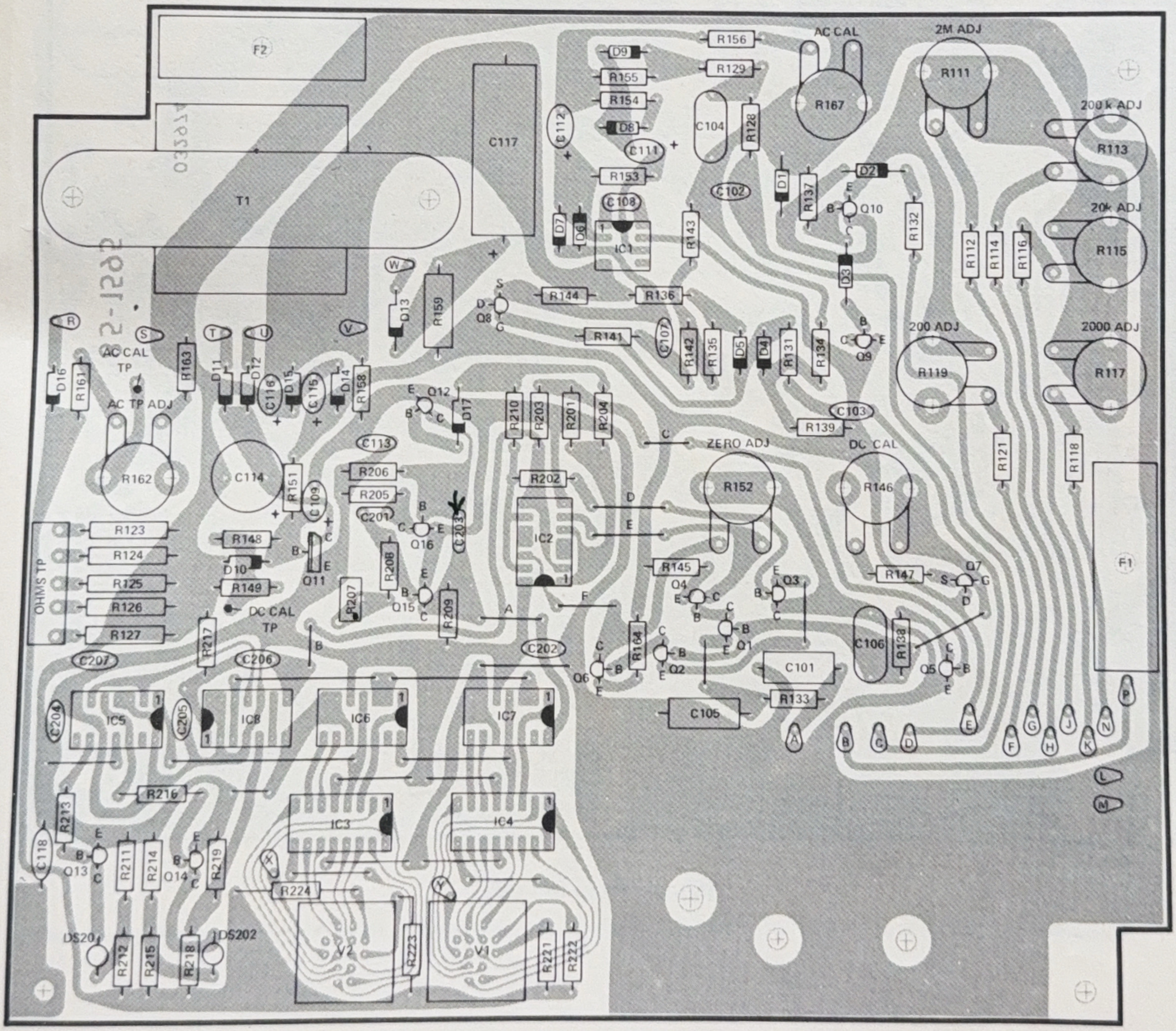
CIRCUIT BOARD X-RAY VIEWS

NOTE: To find the PART NUMBER of a component for the purpose of ordering a replacement part:

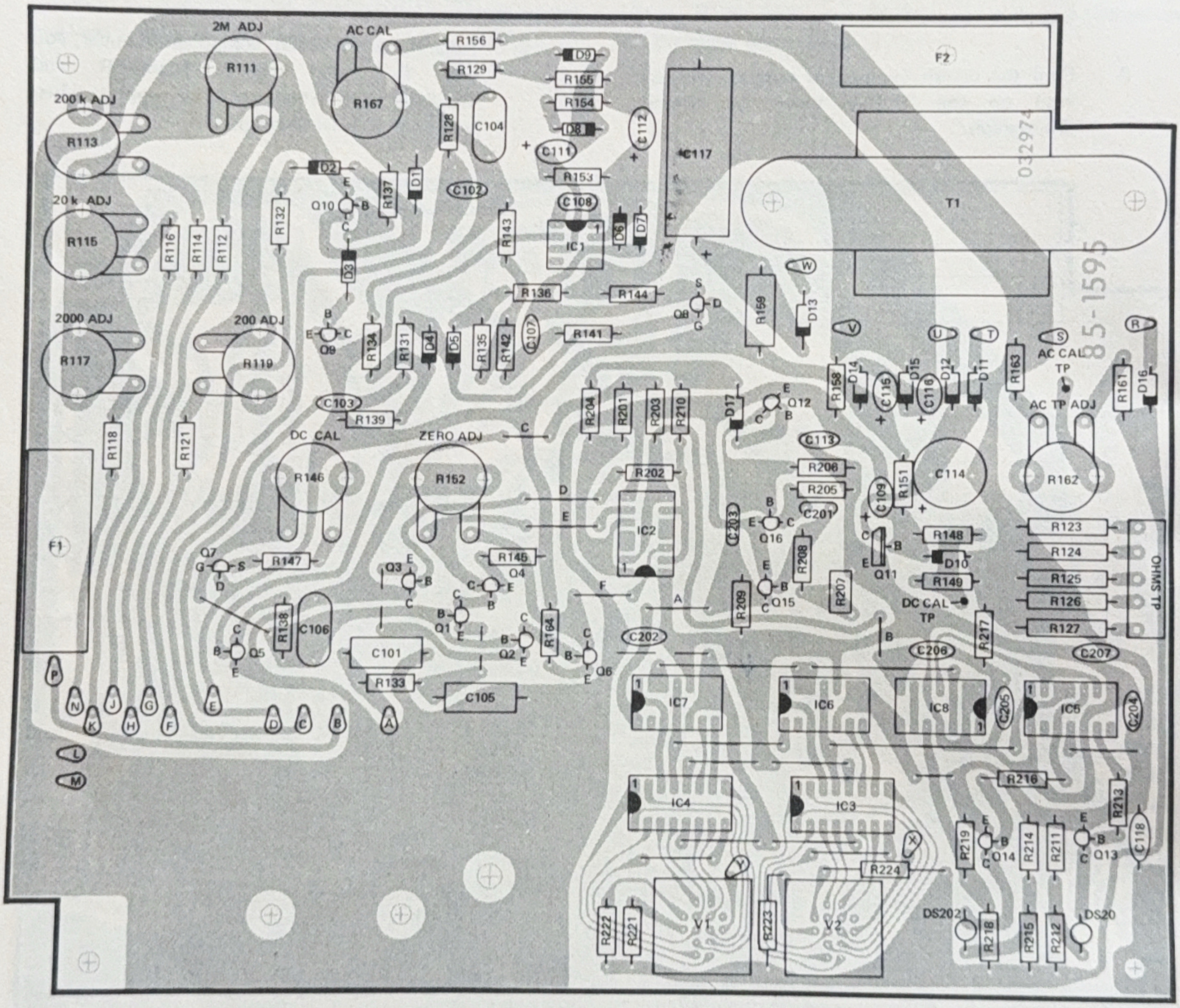
A. Find the circuit component number (R5, C3, etc.) on the "X-Ray View" or "Chassis Photograph."

B. Locate this same number in the "Circuit Component Number" column of the "Parts List" in the front of this Manual.

C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.



(SHOWN FROM COMPONENT SIDE)

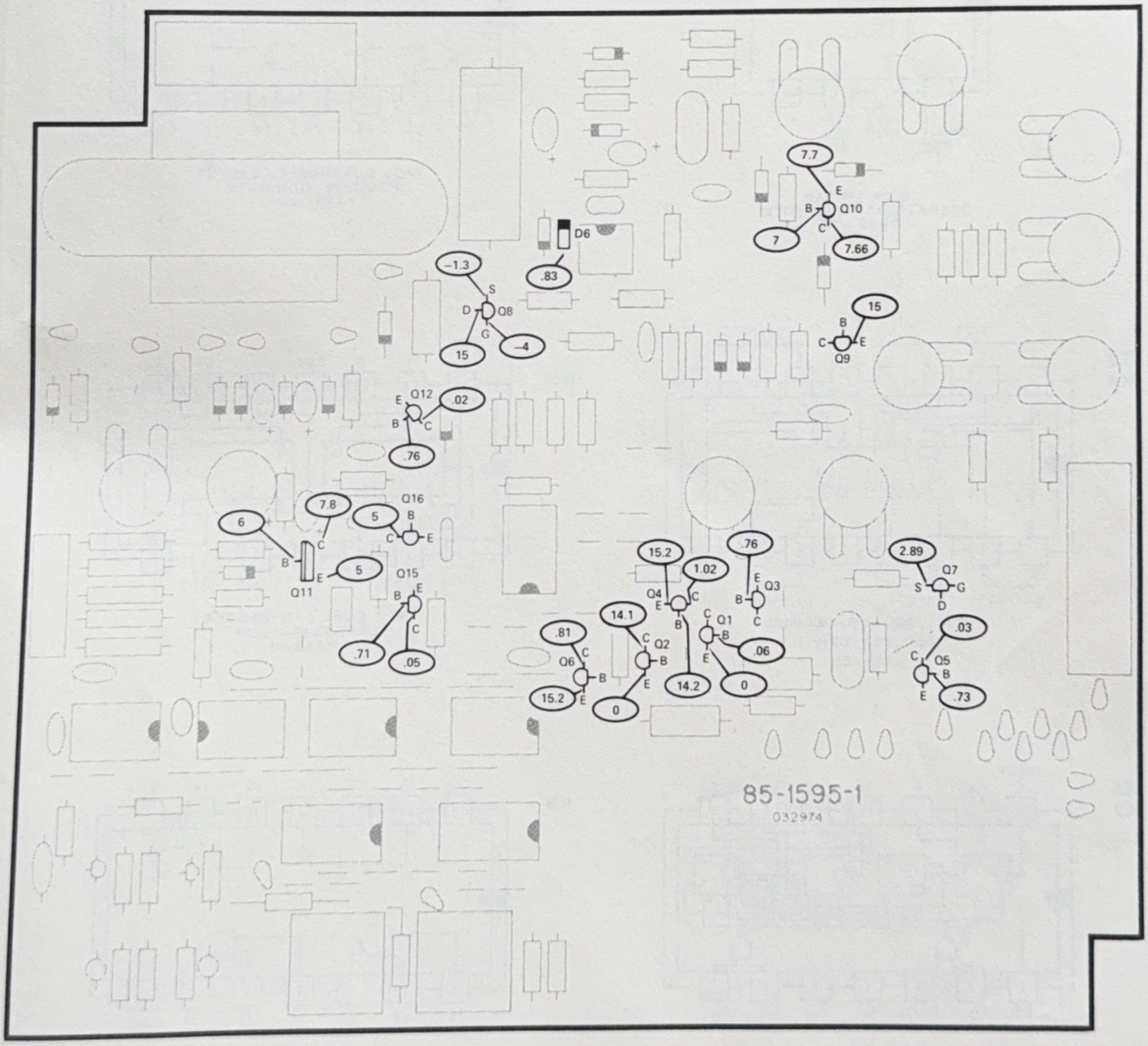


(Shown from foil side)

CIRCUIT BOARD VOLTAGE CHART

NOTES:

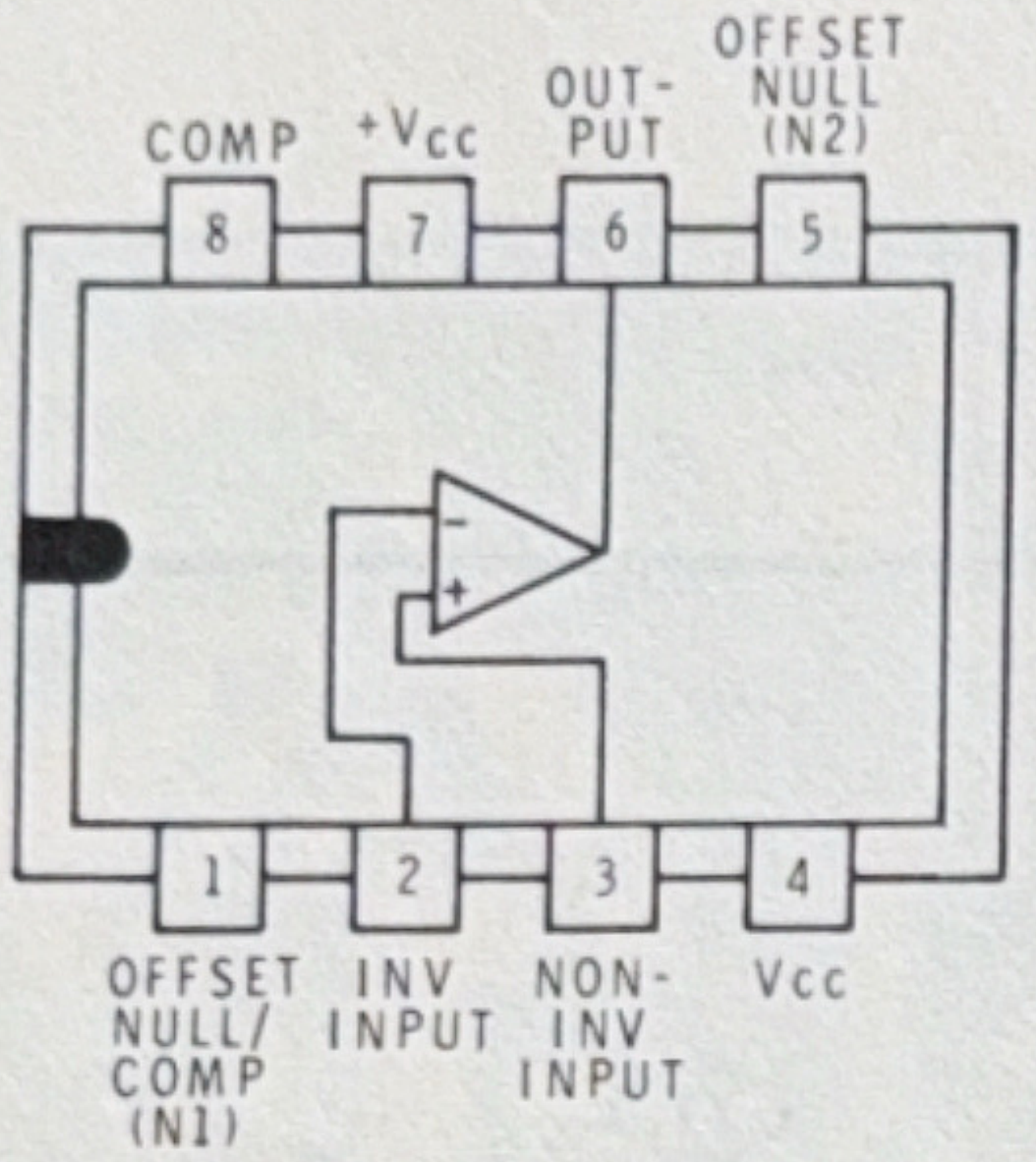
1. Voltages may vary ±20%.
2. Input shorted to C (ground), switch SW1 at DCV, switch SW2 at 2.



INTEGRATED CIRCUIT PIN-OUT DIAGRAMS

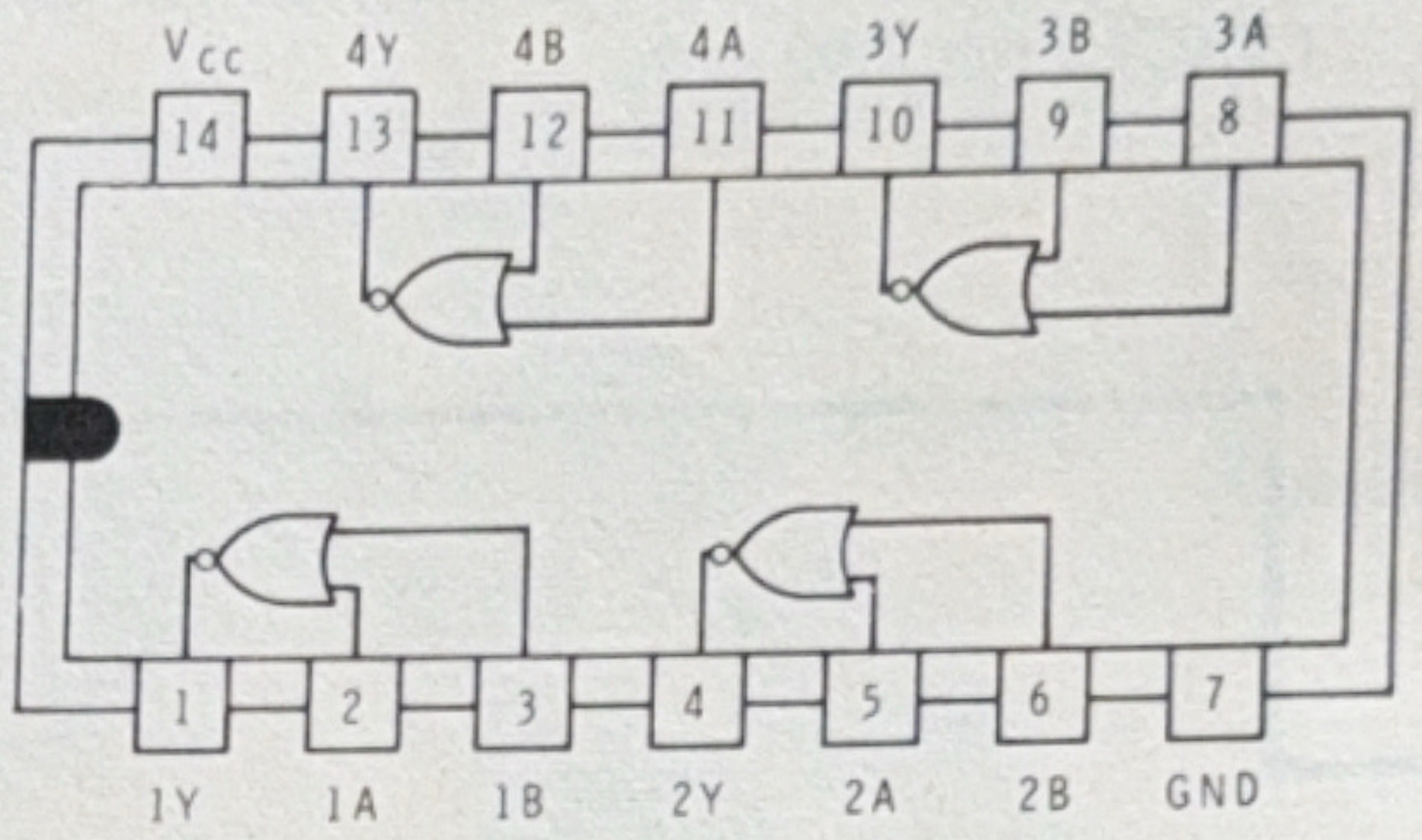
(ALL DIAGRAMS SHOWN FROM TOP)

IC1



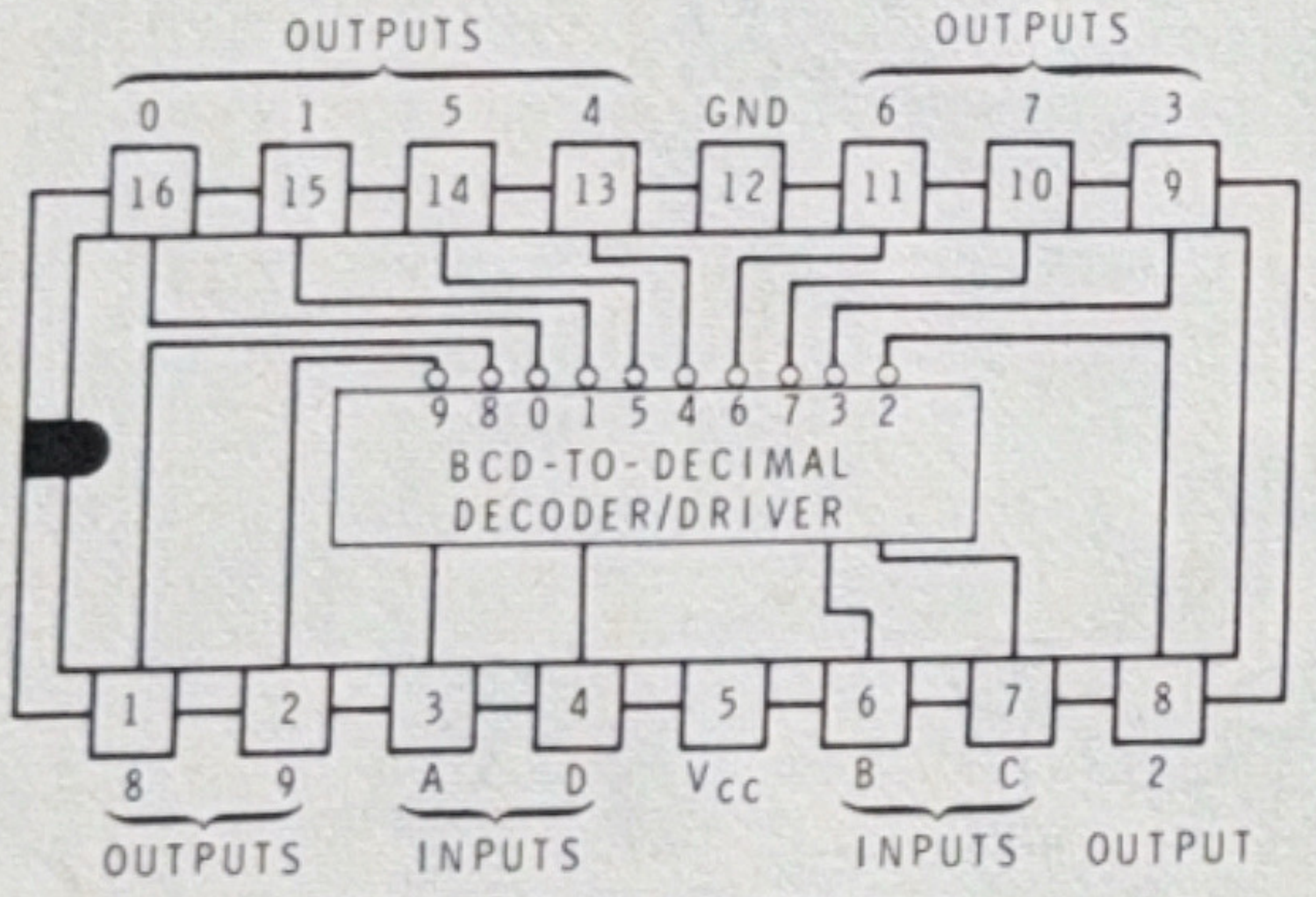
301A LINEAR
OPERATIONAL AMPLIFIER
#442—39

IC2



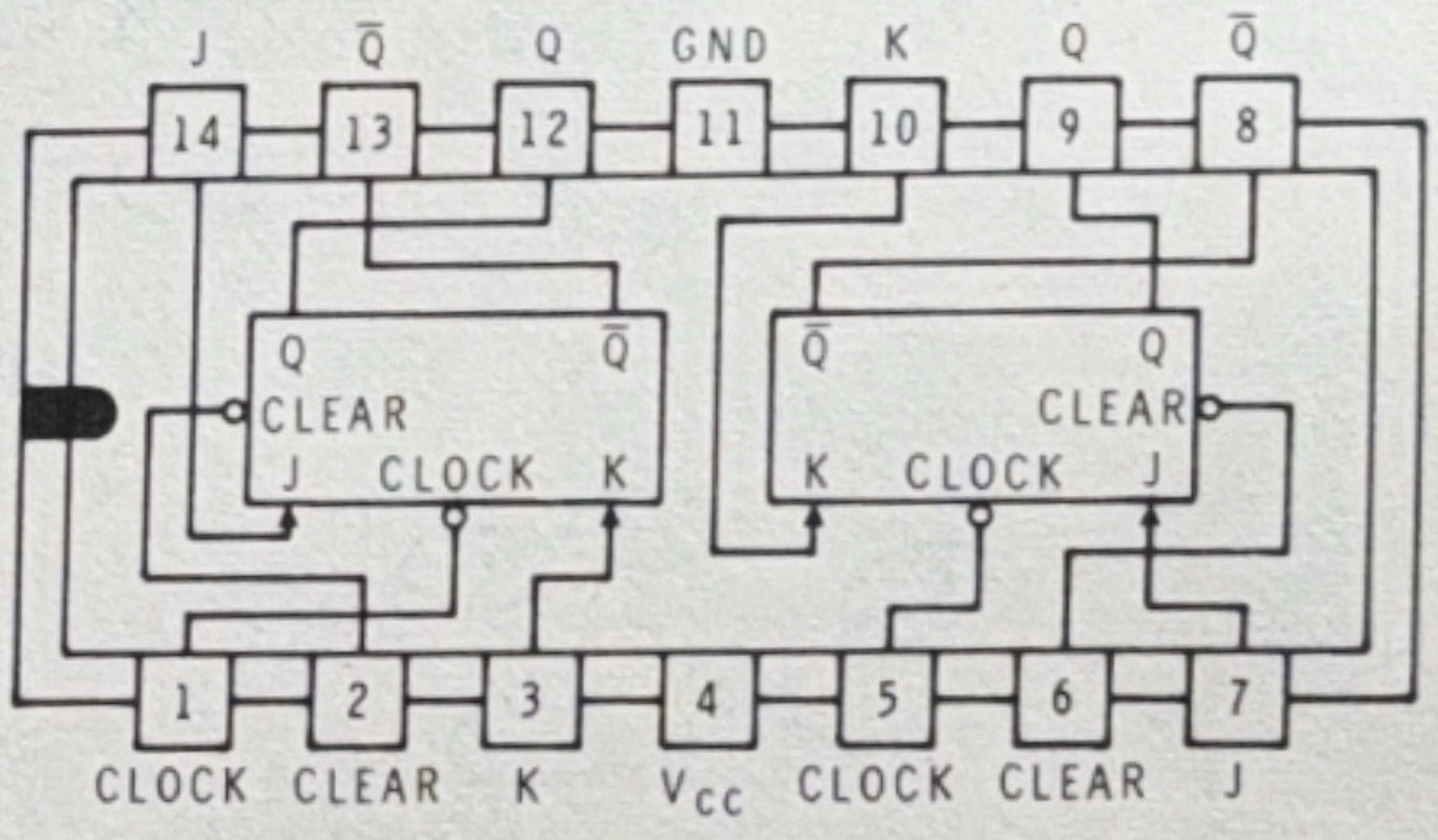
7402 QUADRUPLE—2 INPUT
POSITIVE NOR GATE
#443—46

IC3
IC4



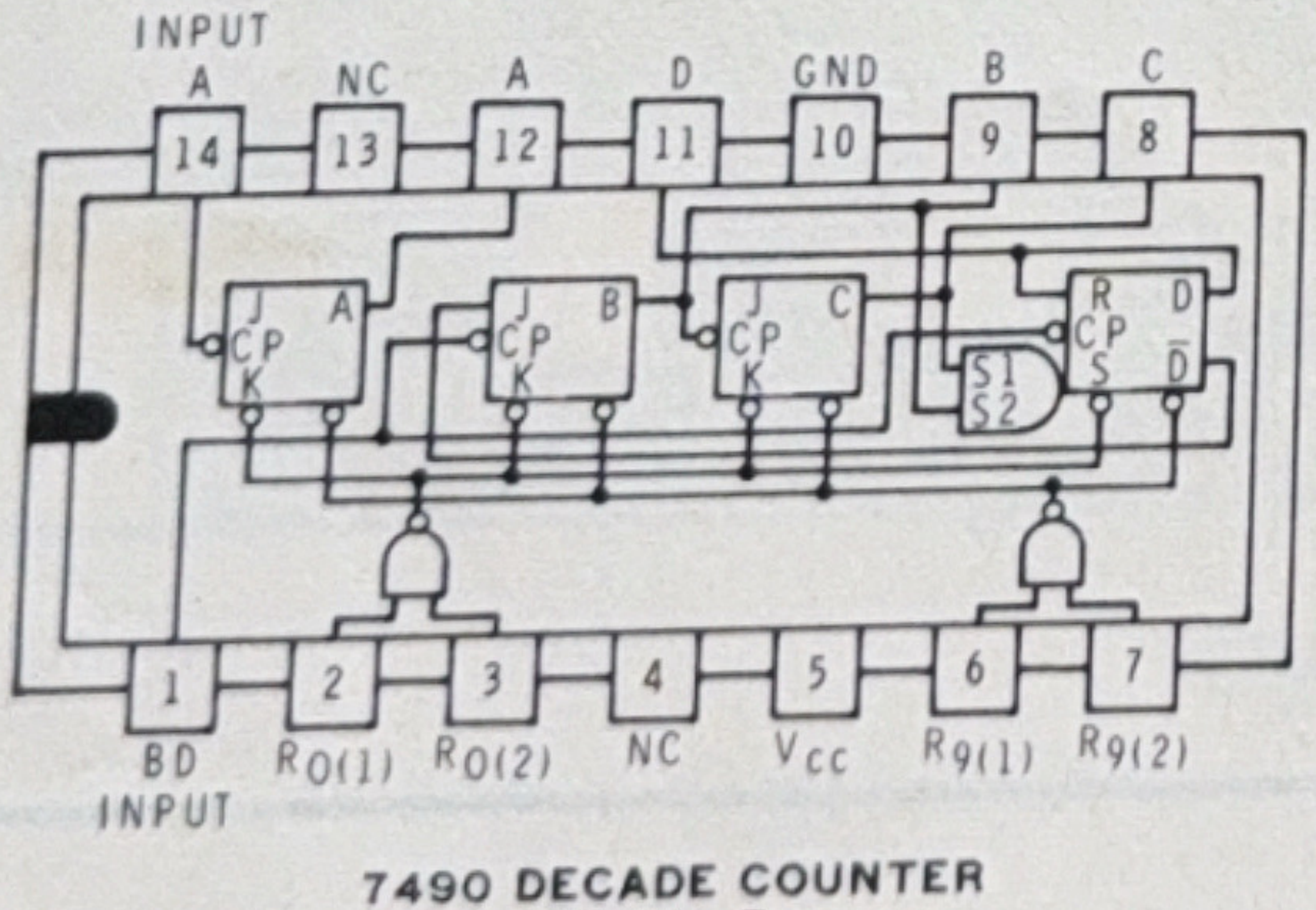
7441 BCD—TO—DECIMAL
DECODER/DRIVER
#443—35

IC5



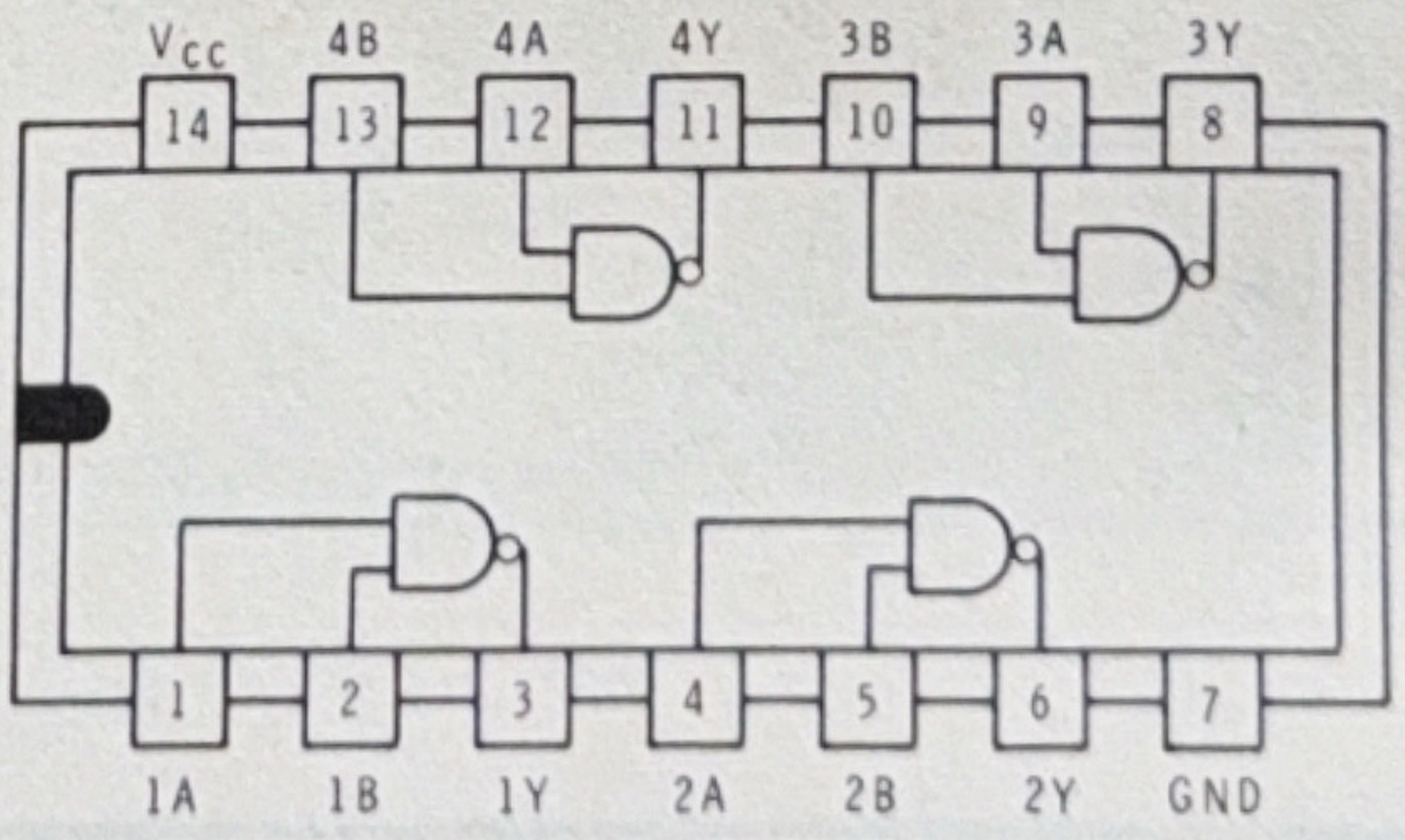
7473 DUAL J—K MASTER
SLAVE FLIP—FLOP
#443—5

IC6
IC7



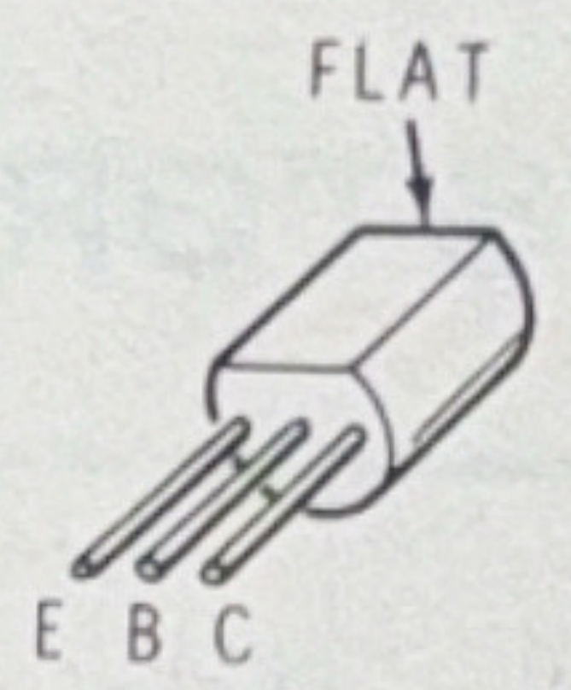
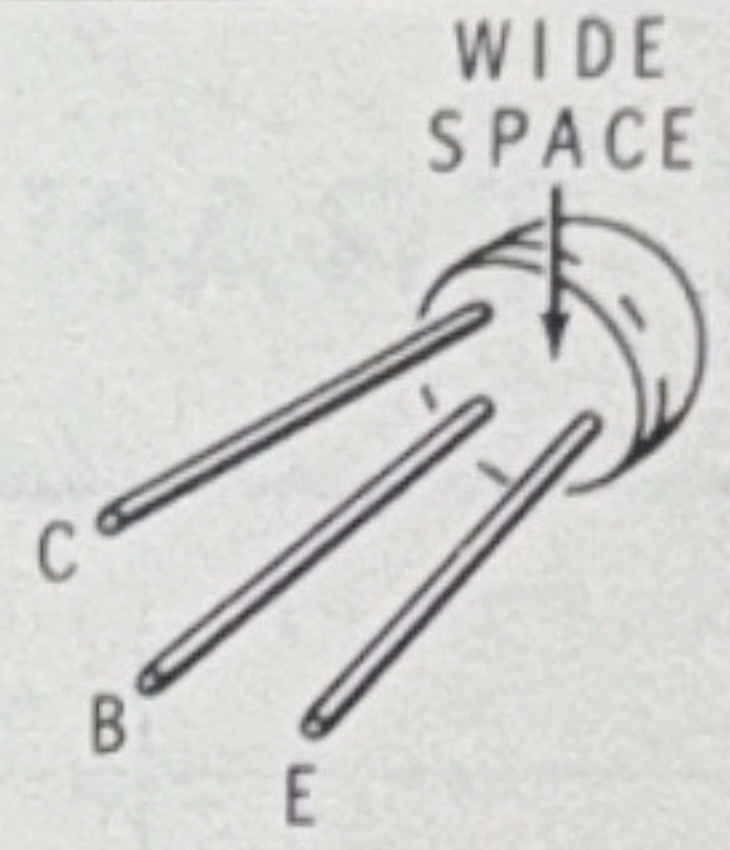
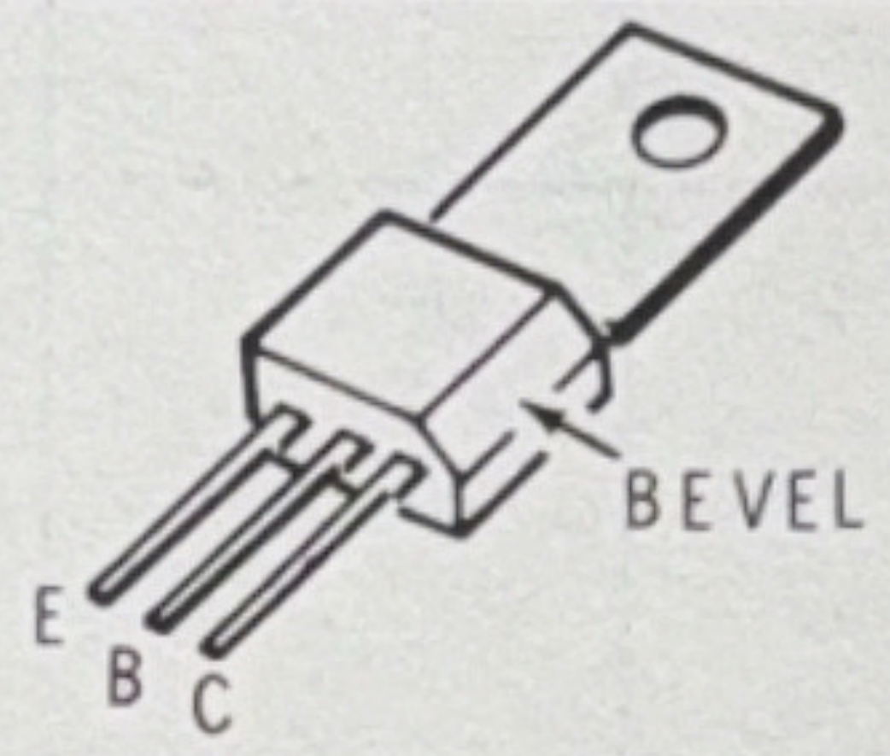
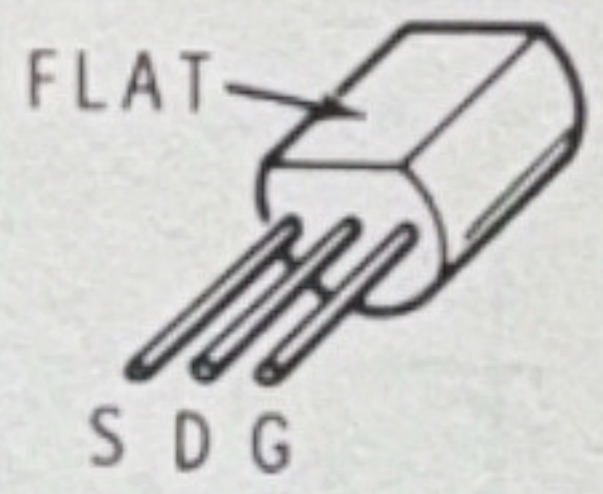
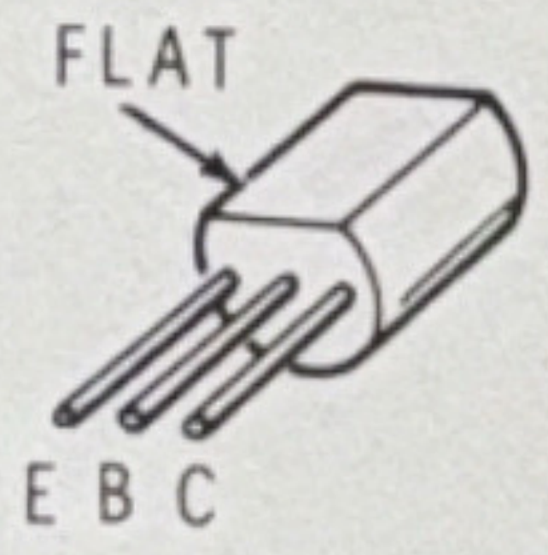
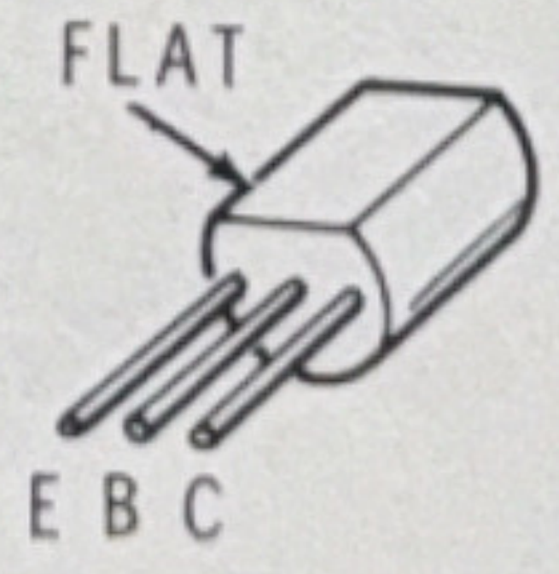
7490 DECADE COUNTER
#443—7

IC8

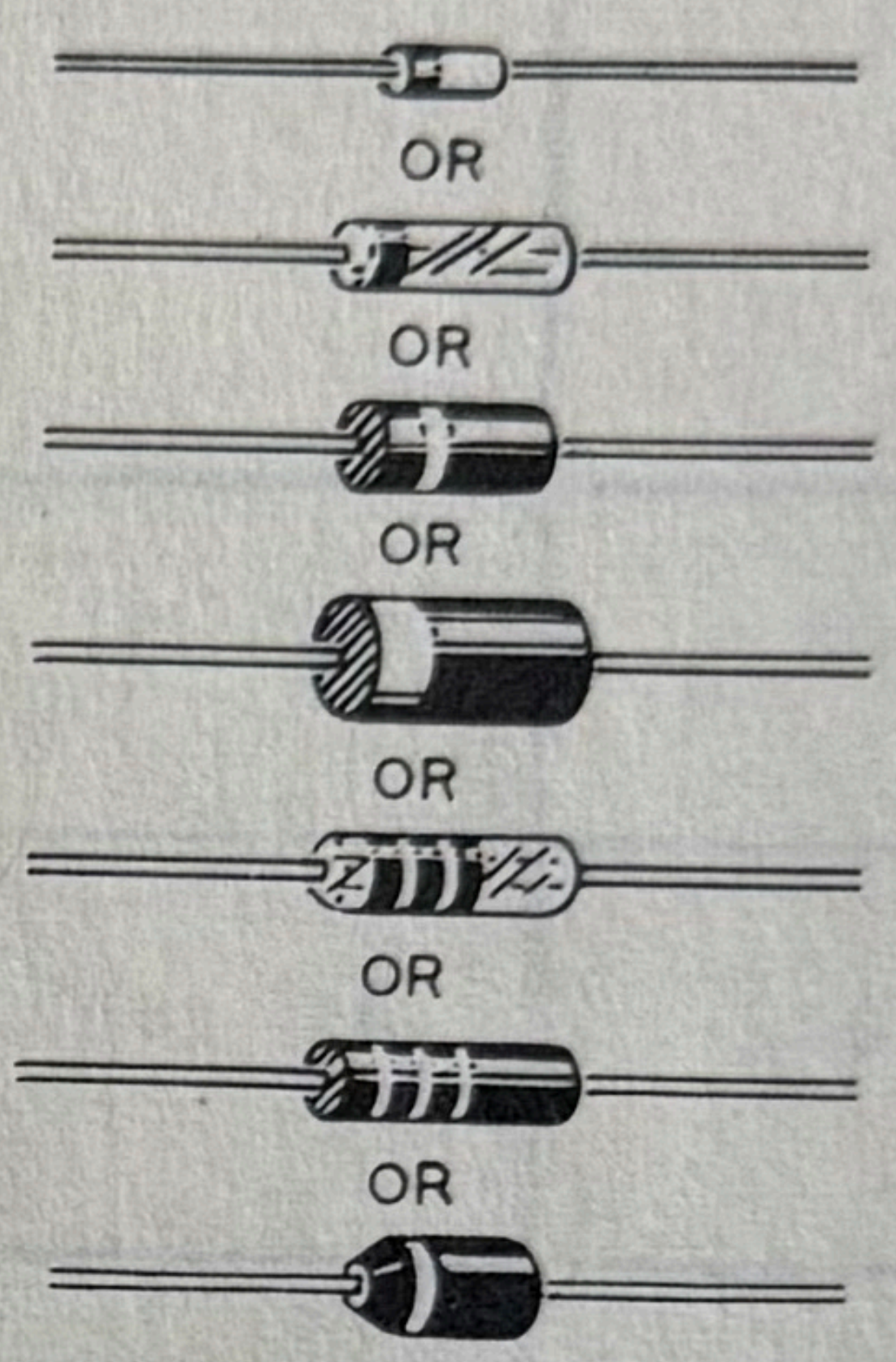


7400 QUADRUPLE 2—INPUT
POSITIVE NAND GATE
#443—1

TRANSISTOR BASING DIAGRAMS

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
Q4, Q6, Q10	417-234	2N3638A	 
Q11	417-272	D40C1	
Q8	417-291	2N5458	
Q7	417-241	EL131	
Q2, Q3, Q5, Q9	417-801	MPSA20	
Q13, Q14	417-294	MPSA42	
Q1, Q12, Q15, Q16	417-134	MPS6520	

DIODE-TRANSISTOR IDENTIFICATION CHART

COMPONENT	HEATH PART NO.	MAY BE REPLACED WITH	IDENTIFICATION
D14, D15	56-25	IN4166A zener	NOTE: HEATH PART NUMBERS ARE STAMPED ON MOST DIODES. 
D3, D4, D5, D6, D7, D8, D9, D17	56-56	IN4149	
D1, D2, D16	57-27	IN2071	
D11, D12, D13	57-65	IN4002	

EXPEDITED PARTS ORDER FORM
(FOR REPAIR PARTS ONLY)

(1) Give Part Numbers as they are in parts list.

(2) Include remittance or permission for C.O.D. shipment. ☐ CASH ☐ C.O.D.

(3) Use separate sheet of paper for all correspondence.

(4) Prices may change to reflect current manufacturing costs.

(5) Current **HEATH** account number AA

PLEASE DO NOT WRITE IN THIS SPACE

KIT MODEL

DATE OF PURCHASE

SERIES NUMBER

QTY.	PART NUMBER	DESCRIPTION	PRICE	TOTAL PRICE	MARK PROPER SPACE FOR WARRANTY PARTS ONLY 3 DAMAGED	 2 DEFECTIVE	 1 MISSING

HEATH COMPANY
BENTON HARBOR
MICHIGAN 49022
PHONE 616-983-7381

NAME

ADDRESS

CITY

STATE ZIP

THIS FORM IS FOR U.S. CUSTOMERS ONLY. OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR.

CUT ALONG DOTTED LINE

EXPEDITED PARTS ORDER FORM
(FOR REPAIR PARTS ONLY)

(1) Give Part Numbers as they are in parts list.

(2) Include remittance or permission for C.O.D. shipment. ☐ CASH ☐ C.O.D.

(3) Use separate sheet of paper for all correspondence.

(4) Prices may change to reflect current manufacturing costs.

(5) Current HEATH account number AA

PLEASE DO NOT WRITE IN THIS SPACE

KIT MODEL

DATE OF PURCHASE

SERIES NUMBER

QTY. | PART NUMBER | DESCRIPTION | PRICE | TOTAL PRICE | MARK PROPER SPACE FOR WARRANTY PARTS ONLY 3 DAMAGED | 2 DEFECTIVE | 1 MISSING

HEATH COMPANY
BENTON HARBOR
MICHIGAN 49022
PHONE 616-983-7381

NAME

ADDRESS

CITY

STATE ZIP

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SCHEMATIC OF THE HEATHKIT® DIGITAL MULTIMETER MODEL IM-1212

NOTES:

1. RANGE SWITCH IS REFERRED TO AS SW2.
2. FUNCTION SWITCH IS REFERRED TO AS SW1.
3. SWITCH WAFERS ARE REFERRED TO AS " WAFER 1 " AND " WAFER 2 " AS VIEWED FROM THE SHAFT END OF THE SWITCH.
4. SW1 AND SW2 ARE SHOWN IN THE COUNTERCLOCKWISE POSITION.
5. SYMBOLS AND THEIR MEANINGS FOLLOW:
   - ▽ CIRCUIT BOARD GROUND.
   - ≡ CHASSIS GROUND.
   - ⬭ POSITIVE DC VOLTAGE.
   - ⊖ NEGATIVE DC VOLTAGE.
   - □ CIRCUIT BOARD HOLE.
6. V_{CC} = 5 VOLTS DC (NOMINAL).
7. RESISTOR VALUES ARE GIVEN IN OHMS (K=1000, M=1,000,000). ALL RESISTORS ARE 1/2 WATT, 10% TOLERANCE UNLESS MARKED OTHERWISE.
8. ALL CAPACITOR VALUES 1 AND OVER ARE IN pF UNLESS MARKED OTHERWISE. CAPACITOR VALUES LESS THAN 1 ARE IN µF.
9. FOR ADDITIONAL INFORMATION ON SOLID STATE DEVICES, REFER TO THE "DIODE-TRANSISTOR IDENTIFICATION CHART" ON PAGES 63 AND 64 AND TO THE "INTEGRATED CIRCUIT PIN-OUT DIAGRAMS" ON PAGE 62.
10. REFER TO THE "X-RAY VIEWS" AND "CHASSIS PHOTOGRAPHS" FOR THE PHYSICAL LOCATION OF PARTS.
11. ARROWS OUTSIDE CIRCUIT BOARD LINES POINT DIRECTLY TOWARD THEIR RESPECTIVE LOCATIONS AT OTHER POINTS ON THE SCHEMATIC.

SCHEMATIC OF THE
HEATHKIT®
DIGITAL MULTIMETER
MODEL IM-1212

CUSTOMER SERVICE

REPLACEMENT PARTS

If you need a replacement part, please fill in the Parts Order Form that is furnished and mail it to the Heath Company. Or, if you write a letter, include the:

- **Part number** and **description** as shown in the **Parts List.**
- Model number and Series number from the blue and white label.
- Date of purchase.
- Nature of the defect.

Please do not return parts to the factory unless they are requested. Parts that are damaged through carelessness or misuse by the kit builder will not be replaced without cost, and will not be considered in warranty.

Parts are also available at the Heathkit Electronic Centers listed in your catalog. Be sure to provide the Heath part number. Bring in the original part when you request a warranty replacement from a Heathkit Electronic Center.

NOTE: Replacement parts are maintained specifically to repair Heathkit products. Parts sales for other reasons will be declined.

TECHNICAL CONSULTATION

Need help with your kit? .... Self-Service? .... Construction? .... Operation? .... Call or write for assistance. You'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label.
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek. . please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit C.O.D. for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

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PHONE 616-983-3961 TLX 72-9421

February 12, 1975

IMPORTANT NOTICE

Please make the following changes in your Manual before you start to assemble your Digital Multimeter.

Page 4 – Foldout, "Parts Pictorial."

At the bottom of the third section from the left, change the part designated as "L12" to "M7."

Near the center of the fourth section from the left, change the part designated as "M7" to "L12."

Page 27 – Draw a circle around the first paragraph in the left column. Then make a line, with an arrowhead, to indicate that you should read this paragraph on Page 26, before the steps in the right column.

Page 41 – Left column, under "Ohms Calibration," change the second step to read:

( ) Remove the black test lead plug from the front panel "V" jack. Connect the alligator clip to fuseholder F1 lug 2 as shown in Figure 2-2.

Page 27 – Cut Detail 4-4A from the bottom of this letter and tape it in place along the top edge of Page 27 in your Manual.